GUIDANCE FOR TEMPORARY SOIL STABILIZATION

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State of California
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Appendices

The main purpose of this *Guidance for Temporary Soil Stabilization* document is to help direct the planning, selection, and implementation of Caltrans-approved temporary soil stabilization Best Management Practices (BMPs). The document also provides a brief review of water quality monitoring of construction sites, as well as, solutions to common soil stabilization problems experienced on the Caltrans right of way.

This document is specifically designed to provide the Resident Engineer with guidance for the approval of soil stabilization BMPs selected by the Contractor. Users of the document are responsible for working within their capabilities acquired through their training and experience, as well as the consultation and advice of the appropriate experts. For optimum results, the manual is to be used in conjunction with the *Caltrans*, *Storm Water Quality Handbooks:*

- *Project Planning and Design Guide (PPDG)*

  http://www.dot.ca.gov/hq/oppd/stormwtr/PPDG-stormwater-2002.pdf

- *Storm water Pollution Prevention Plan (SWPPP) and Water Pollution Control Program (WPCP) Preparation Manual*

  http://www.dot.ca.gov/hq/construc/stormwater/SWPPP_Prep_Manual_3_03.pdf

- *Construction Site Best Management (BMPs) Manual*.

  http://www.dot.ca.gov/hq/construc/stormwater/CSBMPM_303_Final.pdf

Sections 1.1 through 1.3 of this manual include information on the following subjects in respective order.

- Organization of this manual
- Storm water program documents
- The erosion and sedimentation process

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SECTION 1.1
Organization of This Manual

This document is organized into five sections. Each section provides the Resident Engineer with tools for planning, selecting, and implementing appropriate soil stabilization BMP(s).

- **Section 1** is an introductory section. It provides the reader with an overview of the purpose of the document. The section also reviews the storm water program documents and basic erosion processes.

- **Section 2** provides a brief overview of the planning, selection, and implementation of temporary soil stabilization BMPs. It also provides a brief overview of the inspection and maintenance requirements, as well as a detailed discussion of alternative temporary soil stabilization BMPs, including: descriptions, limitations, standards and specifications, and the applicability of temporary soil stabilization BMPs to construction sites based on site-specific characteristics. The information provided in this section will assist in the approval of temporary soil stabilization BMPs selected by the Contractor. The section also provides a brief description of other soil stabilization and sediment control BMPs that can be used in conjunction with the alternative soil stabilization BMPs.

- **Section 3** provides a brief overview of the storm water monitoring requirements. It is designed to assist the Resident Engineer in understanding the Contractor responsibilities for monitoring storm water that may discharge from a construction site into a 303(d) listed water body.

- **Section 4** provides an overview of common soil stabilization problems encountered on Caltrans right-of-way and solutions to these problems.

- **Appendices** documents include: manufacturer and distributor information, a site questionnaire and selection flowchart to assist in the approval of selected soil stabilization BMPs, and a glossary of acronyms and terms that may be used in discussions regarding temporary soil stabilization.

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SECTION 1.2
Storm Water Program Documents

The storm water management program documents listed below are required to address regulations set forth in The Federal Water Pollution Control Act of 1972; (The Clean Water Act), mandated by the United States Environmental Protection Agency. Consult the District Storm Water NPDES Coordinator for further information regarding the storm water program documents.

Storm Water Management Plan (SWMP)

The Statewide Storm Water Management Plan is prepared by Caltrans and provides guidance for management and of pollutants discharged to storm water drainage systems that serve highways and highway-related properties, facilities, and activities. It identifies how Caltrans will comply with the provisions of the Caltrans Permit issued by the California State Water Resources Control Board (SWRCB) on July 15, 1999.

Storm Water Pollution Prevention Plan (SWPPP)

The Construction General Permit requires that all storm water discharges associated with construction activities that result in soil disturbance of at least 0.4 hectare (1 acre) of total land area must comply with the provisions specified in the Caltrans Permit, including the development and implementation of an effective SWPPP. Caltrans' SWPPPs address storm water pollution controls for construction projects.

SWPPP documents may include one or more small projects in the same corridor considered to be part of a larger project, as long as the sum of the disturbed soil area is greater than or equal to 0.4 hectare (1 acre). These smaller projects are subject to the requirements of the Construction General Permit to develop and implement a SWPPP.

Details on the preparation of the SWPPP are found in the supplementary *Storm Water Quality Handbook, SWPPP and WPCP Preparation Manual, March 2003*.

Water Pollution Control Plan (WPCP)

The WPCP is normally prepared by the contractor and is approved by the Resident Engineer prior to soil-disturbing activities. A WPCP must be prepared for soil-disturbing activities that are less than 0.4 hectare (1 acre).

Details on the preparation of the WPCP are found in the supplementary *Storm Water Quality Handbook, SWPPP and WPCP Preparation Manual, March 2003.*

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Erosion

Erosion is the process by which soil particles are detached and transported by the actions of wind and/or water. Erosion occurs naturally due to the influence of climatic forces on the surface of the earth. These same climatic forces, plus the activities of man, such as removal of ground cover, grading, the increase of impervious cover, and/or poor stewardship, can accelerate the process of erosion.

There are a few basic categories of erosion that when combined make up the many variations of erosion. The basic categories of erosion include:

Splash Erosion: When raindrops strike bare soil directly, the impact on the soil can cause the soil aggregates to break apart. The detached soil particles may then be transported due to the action of the water and/or wind.

Sheet Erosion: Sheet erosion can be, but is not always, the means by which soil aggregates are detached from the surface of the soil. It is usually the means by which soil particles, detached by rainfall impact, are transported by the action of shallow sheets of water flowing over the soil surface.

Rill Erosion: Shallow surface flow of sheet erosion seldom flows in a uniform manner for more then a few feet before becoming condensed flow by soil surface irregularities (low spots). The change from shallow sheet flow to condensed flow is accompanied by an increase in velocity and turbulence, which in turn can both break up the soil aggregates and transport the soil particles. Rill erosion occurs when the condensed flow begins to cut well-defined tiny channels (rills), at most a few inches deep, into the soil surface.

Gully Erosion: As the condensed flow cuts rills into the soil surface, the flow within the rills transforms into concentrated flow where velocity and turbulence, increase causing greater erosion. Rills become deeper, wider, and/or combine to become well-defined larger channels (gullies) within the soil surface. Large amounts of soil falling away from a gully’s headwall can be transported by the concentrated flow, resulting in substantial soil loss. Due to undercutting and the force of gravity, gullies can form in both uphill and downhill directions. A large storm event can transform a rill into a gully in a very short amount of time. Once a gully is formed, it can be very difficult and costly to halt or repair.

Channel Erosion: Channel erosion can occur on a large or small scale and in both natural and man-made channels. Channel erosion occurs when the equilibrium between the flow of water and the friction of the soil surface in a channel is disrupted causing the soil aggregates to detach and transported away. Channel erosion can result from an increase in the volume, velocity, and/or duration of flow, the constriction of flow, the removal of streambank bank vegetation, and/or the creation of an unprotected man-made channel.

A large storm event, modifications to the upstream watershed (vegetation removal, increase in impervious surface within the channels tributaries), and/or a constricted flow in a channel can alter the amount, velocity, and/or duration of flow into or within a channel. Channel erosion tends to occur in areas where tributaries, storm drains and/or culverts flow rapidly into an unprotected channel, along channel bends, and/or where flow is constricted.

Sedimentation

Sediment is solid particulate matter (both mineral and organic) that is in suspension, is being transported, or has been moved from its site of origin by air, water, gravity, or ice and has settled elsewhere. Sediment will eventually deposit in receiving waters, storm drains, and/or low spots when the water velocity is reduced and particles settle by gravity. This deposition process is *sedimentation*. The quantity of sediment transported to a measurable point is the *sediment yield*. An increase in sediment yield is reflected by an increase in suspended solids and turbidity. The basic methods of measuring the sediment concentration in water include:

The *suspended sediment concentration (SSC:* The dry weight of all of the solid material from a known volume of a collected water sample.

Total Suspended Solids (TSS): The dry weight of a solid material contained in a known volume of a sample. (e.g. soil particles, algae, aquatic plant/animal waste, particles and waste related to industrial/sewage discharges).

T*urbidity*: The cloudiness of water quantified by the degree to which light traveling through a water column is scattered by the suspended organic and inorganic particles it contains. Scattering of light, increases with a greater suspended load.

SECTION 2.0
Planning, Selection, and Implementation of Temporary Soil Stabilization BMPs

To effectively stabilize disturbed soil areas on construction sites, proper planning, selection, and implementation of soil stabilization BMPs is required. Section 2 is designed to assist the, Resident Engineer in these processes. Should site-specific field conditions require additional measures, consult with a soil stabilization expert.

Section 2.1 provides guidelines on how to plan for temporary soil stabilization, including the following subjects and how each subject pertains to planning for temporary soil stabilization. Where applicable, the (SS-#) is the BMP ID, and is consistent with those identified in the Stormwater Quality Handbooks.

- Rainy Season
- Site Evaluations
    - Flow Conditions
    - Slope Inclination and Slope Length
    - Soil Properties
    - Surface Area
    - Atmospheric Conditions
    - Accessibility of Equipment
    - Drain to 303(d) Listed Water Body
    - Duration of Need
- Scheduling (SS-1)
- Lead Times for Materials and Equipment
- Preservation of Existing Vegetation (SS-2)
- Limit the amount of Exposed Soil
- Soil Preparation
- Weather Tracking
- Timing Installation with Construction Activities and Rainfall
- Year-Round Protection
- Construction Completion

Section 2.2 discusses soil stabilization BMP alternatives. These soil stabilization BMPs are alternatives because they all have the same general function:

- *Binding or coating the soil particles for protection from the erosive forces of water and wind*.

Temporary soil stabilization BMPs alternatives include:

- Hydraulic Mulch (SS-3)
- Hydroseeding (SS-4)
- Soil Binders (SS-5)
- Straw Mulch (SS-6)
- Rolled Erosion Control Products (SS-7)
- Wood Mulch (SS-8)

This information is designed to assist in the selection and implementation of these alternative soil stabilization BMPs by providing descriptions, applications, limitations, standards, and specifications of the BMPs.

Section 2.3 is provides other soil stabilization and sediment control BMP options that may used to compliment the alternative soil stabilization BMPs detailed in section 2.2. These include:

- Earth Dikes, Drainage Swales, and Lined Ditches (SS-9)
- Outlet Protection/Velocity Dissipation Devices (SS-10)
- Slope Drains (SS-11)
- Silt Fences (SC-1)
- Sediment/Desilting Basins (SC-2)
- Sediment Traps (SC-3)
- Check Dams (SC-4)
- Fiber Rolls (SC-5)
- Gravel Bag Berms (SC-6)
- Sand Bag Barriers (SC-8)
- Straw Bale Barrier (SC-9)
- Storm Drain Inlet Protection (SC-10)

SECTION 2.1
Planning for Temporary Soil Stabilization

Planning

Planning is critical to successfully managing storm water at construction sites. Evaluating the construction site for potential storm water impacts, understanding atmospheric conditions, selecting the appropriate BMPs, scheduling construction activities, tracking weather, obtaining the necessary equipment, implementing the appropriate BMPs, and preparing for construction completion are some of the issues related to planning for temporary soil stabilization. Foresight and attention to detail can make the difference in a successful soil stabilization and sediment control plan. Addressing these issues prior to the initiation of construction is essential to successful storm water management.

Regulatory Requirements

In accordance with National Pollutant Discharge Elimination System (NPDES) requirements, Caltrans is required to comply with the provisions of the storm water permit issued by the California State Water Resources Control Board (SWRCB). For information on the federal regulations, Caltrans Permit, Construction General Permit, Phase II Permits, and Caltrans implementation of these permits, refer to *Storm Water Quality Handbook, Construction Site BMP Manual, March 2003.*

Rainy Season

Part of planning for storm water pollution controls is being aware of when and how much precipitation could potentially fall during a storm event in the different regions of the state. The average rainfall in California varies greatly from region to region. The state is separated into three distinct precipitation zones based on the season and the variability in rainfall patterns (See Figure 2.1-1 Designation of Rainy Season). These rainy seasons must be considered in planning the appropriate level and approximate timing of soil disturbing activities, as well as, soil stabilization and sediment control measures.

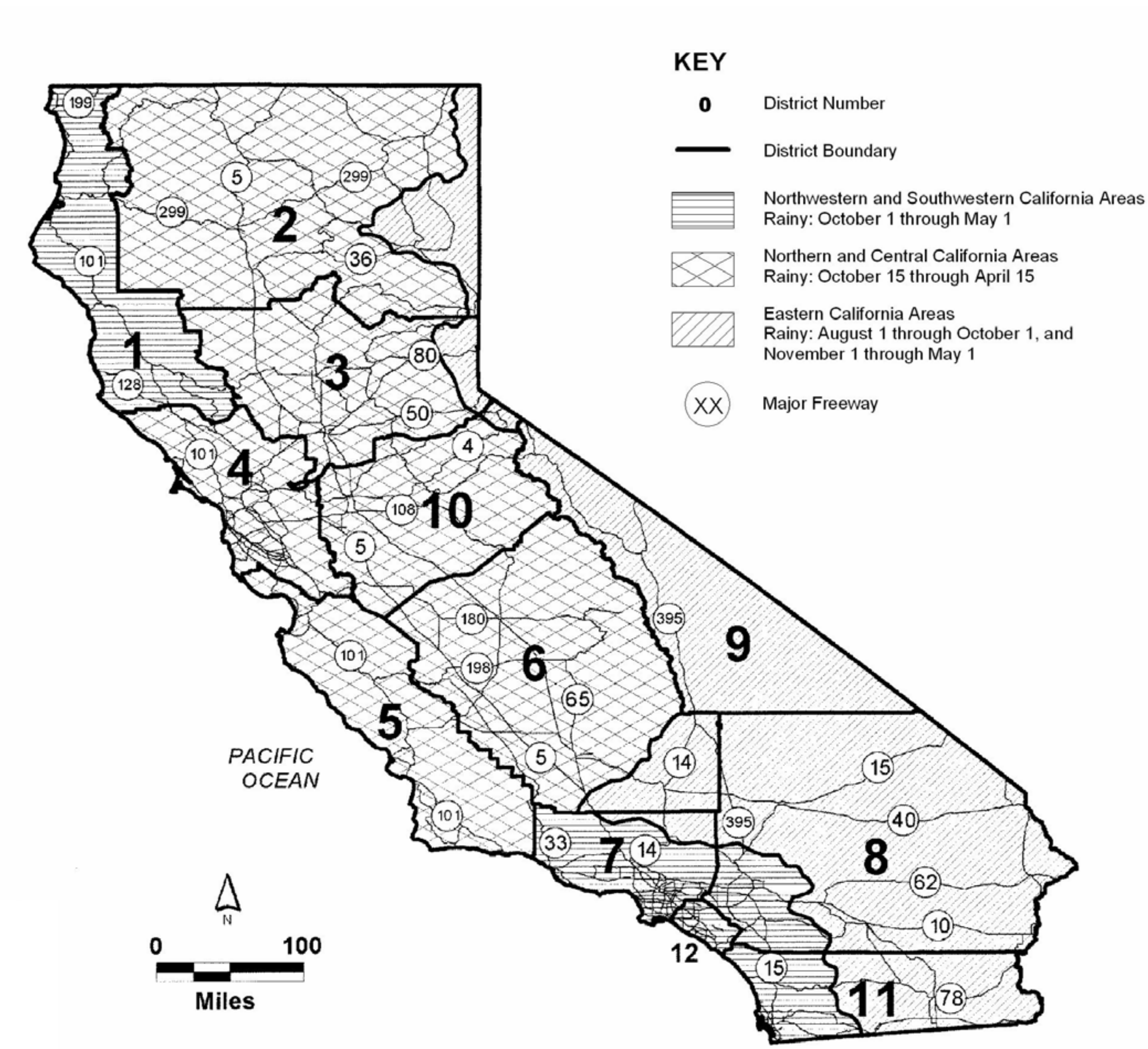
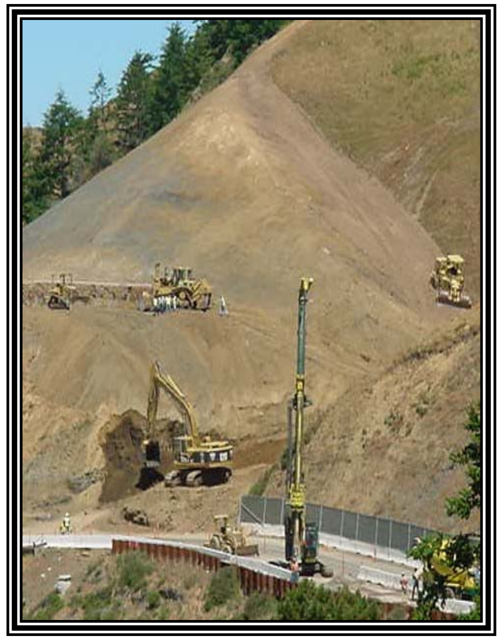


Figure 2.1-1: Designation of Rainy Season

Site Evaluation

Understanding the characteristics of a construction site, (how it will impact storm water and how storm water will impact it), is important for temporary soil stabilization planning for BMP selection. The following characteristics must be considered when selecting BMPs.



- Flow Conditions
- Slope Inclination and Slope Length
- Soil Properties
- Surface Area
- Atmospheric Conditions
- Accessibility of Equipment
- Drainage to 303(d) Listed Water Bodies
- Duration of Need

Flow Conditions

Flow conditions affect the selection of soil stabilization BMPs because many will not withstand channelized or concentrated flows. Therefore, it is essential to determine the type of flow at each construction site in terms of:

Sheet F*low* is not confined, concentrated and/or swift moving, but is spread out over an area. Sheet flow can occur on slopes of any steepness. Although, through the process of erosion, flow will rarely remain sheet flow for an extended period, as rills and gullies will eventually form (rills and gullies could be considered small forms of channelized flow, but will fall under the category of sheet flow).

Channelized Flow is confined between banks and above a streambed, which is typically swift-moving concentrated flow, is considered channelized flow. It can occur in natural streams or man-made channels, earth dikes, drainage swales, and ditches.

Run-on Flow discharges from adjacent drainage areas that drain onto a construction site or disturbed soil area. Run-on flow may be sheet flow or channelized flow and must be slowed, captured, and/or diverted for effective stabilization and erosion protection.

Run-off Flow discharges from the construction site to a down gradient property is run-off flow. Run-off flow may be sheet flow or channelized flow and must be slowed, captured, and/or diverted in order to reduce the potential for erosion and sedimentation impacts to down gradient properties.

Slope Inclination and Slope Length

Slope inclination and slope length are the most important factors affecting the installation of combined soil stabilization and sediment control BMPs, as these factors have the largest potential impact on erosion rates. A combined increase in slope inclination and slope length requires more intensive use of soil stabilization and sediment control BMPs.

Slope inclination is the gradient of the face of an embankment or a stream. It is expressed as a ratio of the vertical to horizontal projection. For the purpose of selecting soil stabilization BMPs, slope inclination ranges are grouped as follows:

- Less than 1:4
- Greater than or equal to 1:4 but less than or equal to 1:2
- Greater than 1:2

The slope length is measured or calculated along the continuous inclined surface. A discrete slope can be measured between one of the following categories:

- From the top of the slope to the toe of the slope (if there are no benches)
- From the top of the slope to the bench directly below within the slope.
- From a bench within the slope to the bench directly below within the slope.
- The lowest bench within the slope to the toe of the slope.

A bench is a drainage feature or a sediment control BMP that intercepts surface flow and conveys the resulting concentrated flow away from the slope.

The slope inclination affects the appropriate selection of soil stabilization BMPs because some soil stabilization BMPs will not function optimally on steep slopes or may require multiple applications to properly stabilize the slope. Slope inclination and slope length together also affect the selection and placement of the appropriate sediment control BMPs. Tables 2-2 and 2-3 Required Combination of Temporary Soil Stabilization and Temporary Sediment Control Barriers (Non-active and Active) *of the Storm Water Quality Handbooks: Construction Site BMPs Manual* describes in further detail the required combinations of temporary soil stabilization and sediment control BMPs for active and non-active areas.

- Active disturbed soil areas are areas where construction is occurring or will occur in the next 21 days.

- Non-active disturbed soil areas are previously active construction areas that will be idle for at least 21 days.

<u>Soil Properties</u>

Refer to the geotechnical report to understand the soil properties of the construction site. This report contains information pertaining to shear strength and density, the grain size distribution, the moisture content, and soil permeability, and chemistry of the soil, as well as, other geological features such as depth to rock, bedding planes and fractures within the soil. Infiltration rates can be calculated and moisture content and permeability values obtained for a particular soil type to aid in selecting soil stabilization BMPs.

Soil Composition

Soil composition analysis includes the classification of grain size, grain shape, and mineralogy. A sieve analysis may be used to determine the grain size distribution (see Table 2.2-a). In the Unified Soil Classification System (See Table 2.2-b) two general groups of soils are recognized:

- predominantly coarse-grained soils (grain size over 0.074mm)

- predominantly fine-grained soils (less than 0.074mm)

The mineralogy of the component particles also dictates the chemical makeup of the soil (e.g., acidic silicate-rich versus basic calcium carbonate-rich soils).

Table 2.1-a: Soil Particle-Size Ranges

Component	Size Range	
	metric	SI
Cobbles	Above 76.2 millimeters	Above 3 inches
Gravel	76.20 millimeters to No. 4 sieve	3 inches to No. 4 sieve
Coarse	76.20 millimeters to 19.05 millimeters	3 inches to 0.75 inch
Fine	19.05 millimeters to No. 4 sieve	0.75 inch to No. 4sieve
Sand	No. 4 to No. 200 sieves	
Coarse	No. 4 to No. 10 sieves	
Medium	No. 10 to No. 40 sieves	
Fine	No. 40 to No. 200 sieves	
Fines (clay or silt)	Below No. 200 sieve (no minimum size)	

Table 2.1-b: Unified Soil Classification System

Major Divisions			Group Symbol	Group Name
Coarse Grained Soils More Than 50% Retained on No. 200 Sieve	Gravel More Than 50% of Coarse Fraction Retained on No. 4 Sieve	Clean Gravel	GW	Well Graded Gravel, Fine to Coarse Gravel
			GP	Poorly Graded Gravel
		Gravel With Fines	GM	Silty Gravel
			GC	Clayey Gravel
	Sand More Than 50% of Coarse Fraction Passes No. 4 Sieve	Clean Sand	SW	Well Graded Sand, Fine to Coarse Sand
			SP	Poorly Graded Sand
		Sand With Fines	SM	Silty Sand
			SC	Clayey Sand
Fine Grained Soils More Than 50% Passes No. 200 Sieve	Silt and Clay Liquid Limit Less Than 50	Inorganic	ML	Silt
			CL	Clay
		Organic	OL	Organic Silt, Organic Clay
	Silt and Clay Liquid Limit 50 or More	Inorganic	MH	Silt of High Plasticity, Elastic Silt
			CH	Clay of High Plasticity, Fat Clay
		Organic	OH	Organic Clay, Organic Silt
Highly Organic Soils			Pt	Peat

From The American Society for Testing and Materials Dietrich et al. (1982)

Shear Strength and Density

Shear strength is defined as the resistance to sliding of one mass of soil against another. Density can be calculated by determining the percent void space in the soil. Greater void spaces between the soil grains results in lower soil density. Soils can be broadly divided into two types:

- Cohesive soils generally contain a large percentage of clay particles which gives the soil cohesive properties.

- Non-cohesive soils are those that do not exhibit cohesive properties. Soils composed of coarse-grained or bulky grains tend to be non-cohesive.

Shear strength tests for cohesive soils are performed and the results reported in the geotechnical report. Density values are reported for non-cohesive soils.

Permeability

Permeability is a measure of how fast water can move through the soil and is often reported in centimeters per second (cm/sec). Provided the soils have good interconnected porosity, the soils with higher permeability will have higher infiltration rates.

Soil Chemistry

A soil chemistry test should be performed prior to selecting the pre-construction and post-construction BMPs, because available nutrients will have an impact on the success of vegetation establishment. Common soil chemistry parameters include: pH, carbon content, total nitrogen, the percent organic matter, phosphorous content and the percent potassium. Variations in soil chemistry result from the composition of the parent rock, water content, the soil's stage of weathering, and the average temperatures of the region. A landscape architect may recommend the application of soil amendments before post-construction re-vegetation. Special care should be given to the selection of soil stabilization BMPs when amendments have been added to the soil.

Geological Features

Soil borings, if performed, give information about the sites vertical geological features such as: depth to rock, orientation of fractures and bedding planes, moisture content, and shear resistance. It is necessary to determine the subsurface geology because the stability of the slope is partly related to the number and orientation of bedding planes, if present. This information should be reviewed before selecting soil stabilization BMPs.

Surface Area

Surface area is the amount of disturbed soil area on the construction site that will require protection from erosion with various soil stabilization BMPs. Surface area categories are grouped in the following way:

- Small: Less Than or equal to 0.4 hectares (1 acre)
- Medium: Between 0.4 hectares (1 acre) and 2 hectares (5.0 acres)
- Large: Greater Than 2 hectares (5.0 acres)

Atmospheric Conditions

Atmospheric conditions on the day of installation can limit the type of BMP that can be applied to the disturbed soil area because some soil stabilization BMPs are not effective in extreme weather conditions such as snow or heat. Other BMPs may require drying times and should not be applied to slopes while it is raining. Climate variations are caused primarily by distance from the coast and elevation. When selecting soil stabilization BMPs consider the temperature ranges, frequency and intensity of rainfall, wind and humidity.

Temperature

If your construction activity is within approximately thirty miles from the ocean, marine air masses tend to moderate temperature and increase humidity. Coastal areas at low elevation will experience little variation in either daily or seasonal temperatures. Summers are mild and relatively dry although fog is often present. Winters are mild and wet.

With distance from the coast temperature differences become more extreme, making inland areas more susceptible to variations in temperature. During the winter frost, ice and snow can occur at higher elevations. During the summer temperatures in inland areas often reach 80 to 100 degrees Fahrenheit. Both situations will affect the selection of soil stabilization BMPs. For example, any BMP containing a stabilizing emulsion will not be applicable in freezing conditions, and the selection of vegetative BMPs will be affected by drought and heat tolerance.

Moisture (Rain) and Humidity

Precipitation is highly seasonal with about 90 percent occurring between October and April (See Figure 2.2-1). During this period, storms come off the Pacific Ocean and move in an eastward or southeastward direction, typically lasting for 1 to 3days.

Distribution of precipitation is influenced by the interaction of air flow and topography. Greater amounts of precipitation fall on slopes that face southwest into the wind. Precipitation increases with elevation, but also decreases with distance from the coast. Therefore the interior river valleys receive less precipitation.

Particularly in the summer, fog is generated as warm moist air flowing from the Pacific Ocean is cooled by cold water welling up along the California coast. The moisture contribution of fog is significant in coastal areas especially during the summer.
During the winter, relative humidity is high throughout the California ranging from 100 percent in the morning to 75-90 percent in the afternoon. During the summer, relative humidity in coastal areas tends to remain around 90 percent, while the relative humidity decreases with distance inland and can drop to less than 10 percent.

Wind

Although winds are generally light, high winds sometimes occur during winter storms, summer thunderstorms, and Santa Ana conditions. The prevailing wind direction from November through March is from the southeast, and during April to October winds usually come from the north or northwest. On the average, wind speeds reach 40 to 50 mph once every two years and 80 to 90 mph every 100 years. Higher winds occur in exposed areas while sheltered forested or developed areas experience lighter winds.

Santa Ana winds are hot, dry winds that occur in southern and central California. Santa Anas are a seasonal phenomena, occurring mostly during fall, winter and spring, tending to peak in December. Winds are driven into coastal southern California when the atmospheric pressure over the inland desert areas exceeds the pressure along the California coast. Winds blow westward through the canyons toward the coastal areas and are often strongest in mountain passes that act as ducts for the continental air flow. This continental air mass is invariably dry, creating relative humidities often less than 25 percent.

Accessibility of Equipment

The accessibility of equipment refers to whether a road or pad capable of supporting equipment for applying soil stabilization BMPs is within range of the disturbed soil area. If the construction site is not accessible only soil stabilization BMPs applied manually are applicable.

Drainage into Section 303(d) Listed Water Body

Within the Clean Water Act regulations, Section 303(d) listed water bodies that are impaired by various pollutants and are designated for developing Total Maximum Daily Loads (TMDLs). If a construction site drains into a Section 303(d) listed water body, understanding and meeting the required total maximum daily loads is essential for compliance. The list of Section 303(d) water bodies in California can be found at:

http://www.swrcb.ca.gov/tmdl/303d_lists.html

Resolution 2001-046 requires sampling of the visible pollutants; suspended sediment concentration (SSC), the total suspended solids (TSS), and/or the turbidity when a construction site discharges to a water body that is listed for sediment, siltation, or turbidity. If the construction site drains to a water body listed for other non-visible pollutants and the construction site has activities that can contribute these non-visible pollutants sampling is required. Sampling must also be conducted for constituents of exposed potential sources if the construction site drains to a listed water body whether or not the water body is listed for these constituents. A copy of resolution 2001-04 can be obtained at:

http://www.stormwatertaskforce.org/

it is essential to understand site run-off dynamics and control needs. The limitations of the soil stabilization BMPs with respect to their potential water quality impacts must clearly be understood. Proper selection and installation of soil stabilization BMPs can facilitate compliance by eliminating pollutants that discharge into Section 303(d) listed water bodies. If discharges cannot be mitigated, sampling for visible and non-visible pollutants is required. Examples of visible pollutants are sediment and turbidity; non-visible pollutants are chemicals that may leach from a soil binder or hydraulic mulch or pollutants from construction equipment or materials. In either case, the presence of visible or non-visible pollutants triggers a monitoring provision under the construction general permit. Refer to Section 3.0 Storm Water Quality Sampling for further details of sampling.

Duration of Need

The time soil stabilization BMPs are needed will depend on the construction schedule and has a direct correlation to the longevity of the temporary soil stabilization BMP. Longevity ranges are typically:

- Less than or equal to 3 months
- Between 3 and 12 months
- Greater than or equal to 12 months

Scheduling (SS-1)

The primary function of scheduling is to coordinate the timing of activities to reduce on-site erosion and off-site sedimentation. The schedule should clearly illustrate when soil disturbing and stabilization activities are planned relative to the rainy season, and should detail rainy season implementation and deployment of temporary soil stabilization and sediment control BMPs. This will minimize the amount and duration of soil exposed to erosion by wind, rain, runoff, and vehicle tracking, while simultaneously ensuring the construction project stays on schedule.

Effective scheduling includes preparing the site prior to the commencement of construction activities. For example, when soil disturbing activities such as clearing and grubbing, contour grading, and embankment construction are necessary, ensure that sediment control measures are in place prior to those activities. Disturbed soil areas should be stabilized quickly by providing cover with vegetative or inert materials to protect the soil from erosion and reduce the need for sediment controls downstream. A construction schedule including BMP implementation must be incorporated into the SWPPP or WPCP. Details of the appropriate applications, limitations, standards and specifications, and inspection and maintenance are provided in the *Storm Water Quality Handbooks: Construction Site BMPs Manual, March 2003.*

Lead Times for BMP Materials and Equipment

The lead time for obtaining BMP materials and the equipment needed to install the BMPs is critical. For temporary soil stabilization BMPs, the lead time can vary from 3 days up to 2 weeks. If equipment is not provided by a local supplier or if the construction site is in a remote location, up to 4 weeks should be allowed for ordering new hydroseed and hydraulic mulch equipment and up to a week for delivery. For renting equipment, at least 3 to 7 days notice may be required; possibly more if the inventory is currently in use. Hydroseeding contractors require up to 2 weeks advance notice to gather materials and be ready to perform hydroseeding or hydraulic mulching. Also be aware that manufacturers may also need more time depending on the demand and season.

Factors to be addressed in order to select the appropriate soil stabilization and sediment control BMPs include:

- Delivery Time
- Time of Installation
- Time Until Effective
- Cost

The time it takes to acquire and install BMPs is essential for selecting the appropriate BMPs. Some BMPs may also require additional time to become effective, for example vegetation may need to be established or a soil binder or hydraulic mulch may need to dry. The cost and availability of the products from local suppliers should be considered as part of the BMP selection. Refer to section 2.2 for other specific limitations and specifications to be considered during the selection process.

Preservation of Existing Vegetation (SS-2)

Preserving and protecting desirable vegetation will provide erosion and sediment control benefits that can substantially reduce the need for additive BMPs, decrease cost, and save time. By preserving existing vegetation, disturbed soil areas are minimized. Contract special provisions may specify the total disturbed soil area allowed and District design teams may further restrict disturbance during the rainy season.

Areas not to be disturbed during construction should be clearly marked on plans and out in the field during the pre-construction phase. Environmentally sensitive areas such as streams, sensitive habitats, or rare vegetative species should also be clearly marked with protective fencing and protected by vegetative buffer zones. Protective fencing will limit damage and access to environmentally sensitive areas. Refer to the *Storm Water Quality Handbook, Construction Site BMP Manual; March 2003* for more information about the preservation of existing vegetation. Specifications for the preservation of existing vegetation are provided in Standard Specifications 7-1.11.

Limit the Amount of Exposed Soil

The size of the disturbed soil area has a direct correlation to the amount of sediment that could potentially be transported from the construction site. Accordingly the amount of disturbed soil area should be limited. Standard Specifications Section 7-1.01G, Water Pollution states

Unless otherwise approved by the Engineer in writing, the Contractor shall not expose a total area of erodible earth, which may cause water pollution, exceeding 7.0 hectares (17.00 acres) for each separate location, operation or spread of equipment before either temporary or permanent erosion control measures are accomplished.

Contract Special Provisions should be used to control the size of the allowable disturbed soil area. The district design teams can reduce the size of a construction sites disturbed soil area during the rainy season to a total of 2.0 hectares (5.0 acres). The Resident Engineer can increase the disturbed soil area beyond 2.0 hectares (5.0 acres) during the rainy season to 7.0 hectares (17.00 acres) provided the appropriate soil stabilization and sediment control BMPs and plan for implementation are included in the SWPPP approved by the Regional Water Quality Control Board.

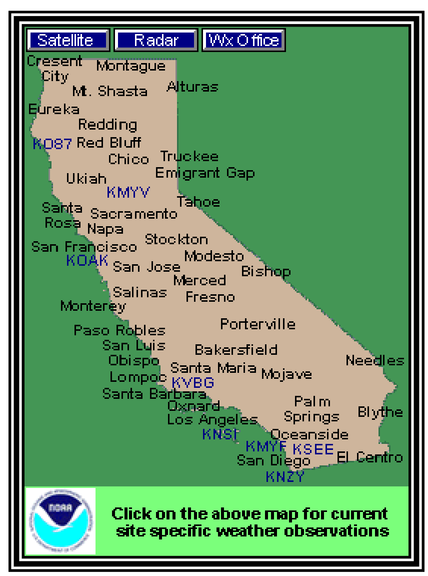
Soil Preparation

Preparing the soil for the application of a BMP includes the removal of loose rock (larger than 60mm), removal of debris, and the breaking of lumps and clods. Placement of topsoil or soil amendments may be necessary if erosion control measures include vegetation establishment, particularly on infertile cut slopes. Refer to the Standard Specifications Sections 20-2.01, 20-2.03, and 20-3.02, for specifications of topsoil, soil amendments, and soil preparation respectively.

Roughening the soil will increase the infiltration rate by loosening the surface of the soil and decrease the rate of erosion. Increasing the infiltration rate also assists in the establishment of vegetation and reduces the need for supplemental irrigation. Roughening must be done to prepare the soil for the application of hydromulch, hydroseeding, soil binders, or wood mulch. Roughing techniques include imprinting, ripping, and sheepsfoot rolling. Track walking is an alternative method of roughening, but should only be used where other methods are impractical.

Before the application of rolled erosion control products, spread the topsoil uniformly across the slope. Rolled erosion control products perform best on even soil surfaces, where maximum soil contact is required to minimize sediment movement.

Weather Tracking



Rainfall prediction is critical to the proper implementation of soil stabilization and sediment control BMPs. Therefore, during the rainy season, one person assigned to each construction project, should be tasked with tracking the weather. Local forecasts and satellite and radar images can indicate the probability and expected intensity of forecasted storms. Weather information is provided on the Caltrans website at:

http://www.dot.ca.gov/siteindex.html

and, clicking on Regional Weather Reports

When evaluating a weather forecast, consider the chance of showers (e.g. 50%) the quantitative precipitation forecast (QPF) (e.g. 1.0 inch), and the intensity (1.0 inch within 6 to 8 hours).

Timing of Temporary BMPs with Rainfall

Non-active disturbed soil areas require implementation of temporary control practices within 14 days from the end of soil-disturbing activities or 1 day before predicted rainfall, whichever occurs first. Active disturbed soil areas need protection before rainfall and throughout each rainy day, requiring adjustment of the construction schedule to allow for these situations.

Year-Round Protection

Soil stabilization and sediment control measures should be utilized year-round since dry season storms, wind, and vehicle tracking can cause erosion during the non-rainy season.

Construction Completion

When an area is no longer designated for construction, permanent vegetation should be applied during the project's defined seeding window. Permanent erosion control is considered functional when the 70 percent of the vegetation is established. The California General Permit for Construction Activities defines this as the condition when a uniform vegetative cover equivalent to 70 percent of the native background cover is achieved or equivalent permanent stabilization measures are in place. When construction is complete and the construction site is stabilized, Caltrans must submit a Notification of Completion of Construction (NOCC) to the appropriate RWQCB.

Table 2.1-c:
Summary of Planning and Implementation of BMPs

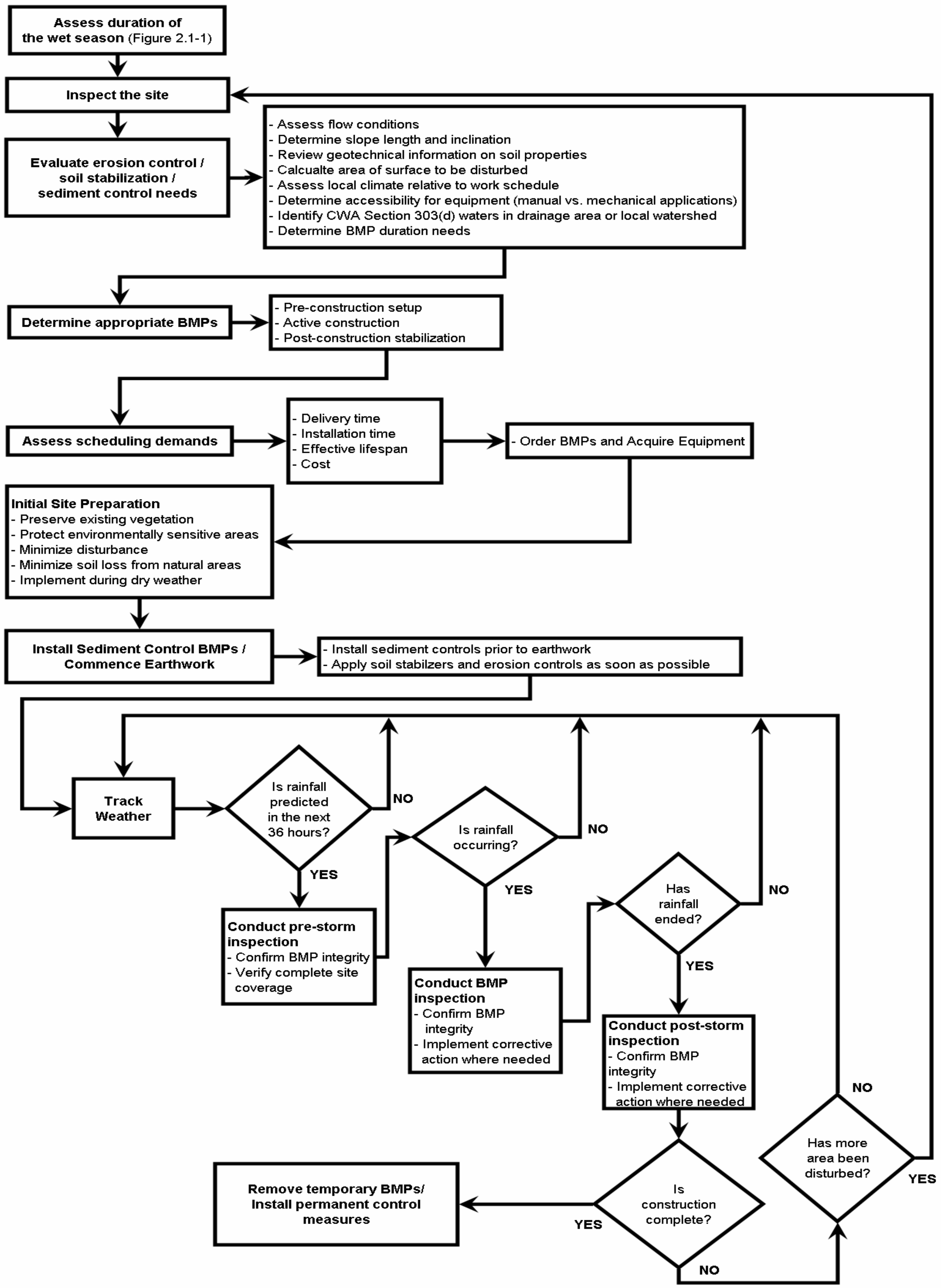


Table 2.1-d: Inspection and Maintenance of BMPs

Installation	***Pre***	• Prior to applying any BMP the Contractor must inspect the disturbed soil area to ensure the soil surface has been properly prepared.
	During	• The Contractor is responsible for the proper installation of all soil stabilization BMPs.
	Post	• After installation, all areas where BMPs have been applied shall be inspected by the Contractor for proper installation and repaired if necessary.
Storm Event	***Pre***	• Prior to an expected rain event, all areas where BMPs have been applied shall be inspected by the Contractor for weak spots and broken/damaged surfaces and repaired as necessary.
	During	• The Contractor is required to have someone on-site to ensure that the BMPs are functioning properly, repair any failures, and/or add address any emergencies. • If the site drains to a 303(d) listed water body the Contractor is responsible for preventing contaminated run-off from discharging into the water body. • During the daylight hours, if the site drains to a 303(d) listed water body and there is a breach, the Contractor must conduct sampling of any storm water containing visible pollutants and/or non-visible pollutants for which the water body is listed. The Caltrans SWPPP/WPCP Preparation Manual, Pollutant Table, Attachment S, identifies the soil binders that do not require sampling.
	Post	• After a storm event, areas where BMPs have been applied shall be inspected by the Contractor for weak spots, damaged surfaces, and/or failures, and repaired or reapplied as necessary.
Maintenance		• The Contractor is responsible for inspecting and maintaining all slopes to prevent erosion. • Refer to the SWPPP, the WPCP, or the Construction Site BMP Manual for inspection and maintenance needs. • Any BMPs that do not provide adequate cover must be reapplied according to a schedule approved by the Resident Engineer or the District Storm Water Coordinator. • If used with vegetation establishment, scheduling inspections and maintenance of vegetation and irrigation is the responsibilities of the Contractor.
Clean up		• Unless the Resident Engineer requests that the BMPs remain in place, contract requirements are to be followed regarding the removal and/or reuse of the BMPs. • BMPs may need to be removed and disposed of in a landfill before the area can be permanently stabilized.

SECTION 2.2
Temporary Soil Stabilization
BMP Alternatives

Temporary soil stabilization BMPs are designed to eliminate or reduce the erosion of disturbed soil areas during the process of construction and reduce the transport of sediment and pollutants by storm water. Sediment is a pollutant, and can also act as a carrier for other pollutants leaving a construction site. These pollutants contaminate storm drains, streams, rivers, lakes, coastal bays and estuaries, and ultimately the ocean. Caltrans has approved six alternative soil stabilization BMPs to be applied to disturbed soil areas in order to eliminate or reduce erosion and the potential transport of sediment and pollutants off of its right-of-way by storm water. These soil stabilization BMPs are alternatives because they all have the same general function:

Binding together the soil particles within or coating the surface of a disturbed soil area in order to protect the disturbed soil area from the erosive forces of water and wind.

- Hydraulic Mulch (SS-3)
- Hydroseeding (SS-4)
- Soil Binders (SS-5)
- Straw Mulch (SS-6)
- Rolled Erosion Control Products (SS-7)
- Wood Mulch (SS-8)

The alternative soil stabilization BMPs can be used in conjunction with each other or used with other soil stabilization and sediment control BMPs to reduce erosion and sediment and pollution transport. The other BMPs used in conjunction with the alternative soil stabilization BMPs are discussed in further detail in Section 2.3 and its subsections.

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Description

Hydraulic mulch is a mixture of wood mulch, and water,) with or without combinations of stabilizing emulsion, recycled paper, and/or, synthetic fibers). This slurry is applied to disturbed soil areas using hydro-mulching equipment to temporarily stabilize the soil and reduce erosion caused by wind and water. There are four types of hydraulic mulches.

- Hydraulic Mulch
- Hydraulic Matrix
- Bonded Fiber Matrix
- Mechanically Bonded Fiber Matrix

<u>Hydraulic Mulch:</u> Hydraulic mulch consists of shredded wood fibers, water, and/or a stabilizing emulsion. Hydraulic mulch can be specified with or without a stabilizing emulsion. Hydraulic mulch is 100 percent biodegradable. The wood mulch and stabilizing emulsion (if specified) are mixed with water in a hydraulic mulcher, and sprayed onto a disturbed soil area as liquid slurry.

<u>Hydraulic Matrix:</u> A hydraulic matrix consists of a stabilizing emulsion combined with wood fiber, paper fiber, and water. Hydraulic matrix can be applied as either a multi-layered layered BMP with a layer of wood fiber as the base and a layer of paper fiber as the top, or a mixture of the wood and paper fibers as one layer. Hydraulic matrix is 100 percent biodegradable. Each constituent is mixed in a hydraulic mulcher, and sprayed onto a disturbed soil area as liquid slurry. If applied as a multi-layer BMP, multiple passes will be required.

<u>Bonded Fiber Matrix:</u> A bonded fiber matrix consists of strands of continuous elongated wood fibers combined with a stabilizing emulsion and water. Bonded fiber matrix is 100 percent biodegradable. The bonded fiber matrix is mixed with water in a hydraulic mulcher and applied onto a disturbed soil area as liquid slurry.

Mechanically Bonded Fiber Matrix: A mechanically bonded fiber matrix consists of strands of continuous elongated wood fibers and/or mechanically (interlocking) bonded synthetic fibers combined with a stabilizing emulsion and water. Mechanical bonded fiber matrix is biodegradable and photodegradable due to the interlocking synthetic fibers. The mechanically bonded fiber matrix is mixed with water in a hydraulic mulcher and applied onto a disturbed soil area as liquid slurry.

Table 2.2.1-a: Limitations of Hydraulic Mulch

Category	*Limitation*
Selection	• Hydraulic mulch consisting of only paper or recycled paper fibers **is not permitted**. Paper is acceptable if incorporated with a biodegradable fiber (such as wood). • Do not be used in areas in which the mulch would be considered unsuitable with immediate future earthwork and would, therefore, need to be removed or reapplied. • The site must be accessible to mulching equipment for hydraulic mulch to be applied.
Installation	• Avoid overspray hydraulic mulch onto existing vegetation, sidewalks, travel ways, sound walls, and channels. • Walking, moving equipment, and/or vehicular traffic across areas where hydraulic mulch is applied will damage the BMP by breaking the crusted surface of the porous mat.
Flow Conditions	• Hydraulic mulch should not be used in areas containing swift-moving concentrated flow or high-volume sheet flow because it has a tendency to be washed away. • When necessary, use with other soil stabilization and sediment control BMPs (see Section 2.3) to reduce the slope lengths and limit run-on flows to the areas where the hydraulic mulch is applied.
Time Until Effective	• Hydraulic mulch requires minimum drying times, therefore, it cannot be applied immediately before rainfall, during rainfall, and/or where standing water is present.
Duration of Need	• Hydraulic mulch is a short-term soil stabilization practice in that it generally lasts through only a portion of the growing/rainy season.
Maintenance	• Reapplication of hydraulic mulch may be necessary to effectively stabilize the soil throughout the season.

Standards and Specifications

The selection of hydraulic mulch by the Contractor must be approved by the Resident Engineer or the District Storm Water Coordinator.

Prior to the application of the hydraulic mulch, the soil surface must be prepared in accordance with the Standard Specifications Sections 20-2.01 and 20-3.02. Also, roughen the soil surface with furrows that trend along the contours. Roughening can be done by ripping or sheepsfoot rolling. Track walking is an alternative method of roughening, but should only be used where other methods are impractical.

Specifications for the wood and paper fibers of hydraulic mulches can be found in Standard Specifications Sections 20-2.07 and 20-2.08.

Combined with hydroseeding (see Section 2.2.2 Hydroseeding), a mixture of hydraulic mulch, water, seeds, and fertilizer can be sprayed over an area of disturbed soil to promote plant growth by providing protection and warmth for the seeds.

Table 2.2.1-b
Applicability of Hydraulic Mulch (SS-3) to Site Characteristics

Type	***Class***	***Flow Conditions***	***Maximum Slope Inclination (V:H)***[(1)]	***Soil Classification***[(2)]	***Surface Area***	***Atmospheric Conditions***	***Accessibility***	***Drains to 303(d) Listed Water Body***	***Duration of Need***[(Y)]
Hydraulic Mulch	***Biodegradable***	sheet	1:2	GM, GC, SW, SP, SM, SC, ML, CL, OL, MH CH, OH, Pt	medium to large	A	B	C,D	3 to 12 months
Hydraulic Matrix	***Biodegradable***	sheet	1:2	GM, GC, SW, SP, SM, SC, ML, CL, OL, MH CH, OH, Pt	medium to large	A	B	C,D	Lees than 3 months
Bonded Fiber Matrix	***Biodegradable***	sheet	1:2	GM, GC, SW, SP, SM, SC, ML, CL, OL, MH CH, OH, Pt	medium to large	A	B	C,D	3 to 12 months
Mechanically Bonded Fiber Matrix	***Biodegradable and Photodegradable***	sheet	1:2	GM, GC, SW, SP, SM, SC, ML, CL, OL, MH CH, OH, Pt	medium to large	A	B	C,D	Greater than 12 months

(1): Conservative Maximum Slope Inclination (V:H) recommended by Caltrans for product applicability, manufacturer may recommend greater slope inclinations
(2): Refer to Table 2.1-b: Unified Soil Classification System for soil classification descriptions.
A: The BMP cannot be applied during a storm event or freezing conditions. Avoid applying in strong winds and over spraying.
B: The disturbed soil area must be accessible to equipment.
C: If disturbed soil area drains to 303(d) listed water body, potential non-visible pollutant.
D: If disturbed soil area drains to 303(d) listed water body, potential pollutants if breach or malfunction occurs.
(Y): Data obtained from the URS Greiner Woodward Clyde, Soil Stabilization for Temporary Slopes, 1999

Table 2.2.1-c
Application Rates of Hydraulic Mulch (SS-3)

Type		*Application Rate$_{(W)}$*	*Guidelines*
Hydraulic Mulch	***kg/ha***	2,250 – 4,500	Some general guidelines to be followed regarding the of application rate and percent soil binder include: • Increase the application rate and percent soil binder (if applicable) as the slope increases. • Increase the application rate and percent soil binder (if applicable) to soils with a high infiltration rate and expansive properties. • Increase the application rate and percent soil binder (if applicable) to roughened soils for complete coverage. • Increase application rate in areas of heavy rainfall.
	lb/ac	2,000 – 4,000	
	% soil binder	0 - 5	
Hydraulic Matrix	***kg/ha***	2,250 – 4,500	
	lb/ac	2,000 – 4,000	
	% soil binder	5 - 10	
Bonded Fiber Matrix	***kg/ha***	3,400 – 4,500	
	lb/ac	3,000 – 4,000	
Mechanically Bonded Fiber Matrix	***kg/ha***	3,400 – 4,500	
	lb/ac	3,000 – 4,000	

(W): Data obtained from Caltrans, Storm Water Quality Handbooks; Construction Site BMP Manual, 2003

Table 2.2.1-d
Time and Cost of Hydraulic Mulch (SS-3)

Type	*Delivery Time$_{(Y)}$*	*Installation Time*	*Time Until Effective*	*Cost of Installation$_{(X)}$*	
	days	***hours/hectare***	***days***	***$/hectare***	***$/acre***
Hydraulic Mulch	3-7	10 [1]	1 to 2	2,200 - 3,230	900 - 1,300
Hydraulic Matrix	3-7	10 [1]	1 to 2	2,200 - 3,230	900 - 1,300
Bonded Fiber Matrix	3-7	10 [1]	1 to 2	12,500 - 16,000	5,000 - 6,500
Mechanically Bonded Fiber Matrix	3-7	10 [1]	1 to 2	12,500 - 16,000	5,000 - 6,500

(1): Assumes a 2 man crew with one 3000 gallon water truck (or access to water) that can cover 2 acres per day. Actual installation time may vary depending on location and field conditions.
(X): Data obtained from the Caltrans, Erosion Control Manual (Draft), Training Materials, 2003
(Y): Data obtained from the URS Greiner Woodward Clyde, Soil Stabilization for Temporary Slopes, 1999

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Description

The addition of temporary vegetation to disturbed soil areas is a Caltrans approved soil stabilization practice. Hydroseeding is the process of vegetating disturbed soil areas by applying a mixture of stabilizing emulsion, seed, fertilizer, and wood fiber to disturbed soil using hydro-mulch equipment. Hydroseeding stabilizes disturbed soil areas, reduces erosion, and provides dust control by dissipating the energy of rain, increasing infiltration, and trapping sediment. Hydroseeding can be applied as a stand alone BMP or in conjunction with other alternative soil stabilization BMPs. Hydroseeding can be applied in the following ways:

- Stand Alone
- Hydraulic Mulch (see Section 2.2.1)
- Soil Binder (see Section 2.2.3)
- Straw Mulch (integrated or with a soil binder see Sections 2.2.3 and 2.2.4)
- Rolled Erosion Control Products (see Section 2.2.5)
- Wood Mulch (see Section 2.2.6)

Table 2.2.2-a: Limitations of Hydroseeding

Category	*Limitation*
Selection	• The effectiveness of hydroseeding can be limited by the increased potential of erosion during the period of vegetation establishment. • Hydroseeding should not be used in areas in which the mulch would be considered unsuitable with immediate future earthwork and would, therefore, need to be removed or reapplied.
Installation	• Some regions may have a limited growing season due to the cold climate. Proper establishment of vegetation must be coordinated with the climatic conditions or seasonal variations of the region. • Some methods of application may require multiple applications (passes). Procedures that require multiple applications can add to the cost. • It can be difficult to establish vegetation on steep slopes and arid climates. Some soil types (e.g. coarse sandy infertile soils on cut slopes) are also difficult to vegetate. • Stable soil temperature and moisture content during the period of germination is essential for the establishment of vegetation. • Vegetation may not be established properly without including supplemental irrigation, which can add significantly to the cost. • Care must be taken not to overspray onto existing vegetation, sidewalks, travel ways, sound walls, and channels. • Walking, moving equipment, and/or vehicular traffic across areas where a hydroseed is applied will damage the BMP by trampling/destroying the seed or the new growth.
Flow Conditions	• Hydroseeding should not be used in areas containing swift-moving concentrated flow or high-volume sheet flow because it has a tendency to be washed away unless used in conjunction with a BMP that can withstand concentrated flows (e.g. TRMs). • When necessary, use with other soil stabilization and sediment control BMPs (see Section 2.3), to reduce the slope lengths and limit run-on flow to the areas where the hydroseed is applied.
Time Until Effective	• Hydroseeding is not an immediate method of soil stabilization. If there is insufficient time to establish the vegetation, hydroseeding must be used in conjunction with SS-3, SS-5, SS-6, SS-7 and/or SS-8
Duration of Need	• Temporary vegetation is not recommended for short durations.
Maintenance	• Reapplication of hydroseed may be necessary to effectively stabilize the soil throughout the season. • If not properly maintained (e.g., mowed or watered), established grasses can become a fire hazard. • Temporary vegetation may have to be removed before permanent vegetation can be established.

Standards and Specifications

The selection of hydroseeding materials must be approved by the District Storm Water Coordinator and Landscape Architect and shall comply with Standard Specifications Section 20-3.04B and any special provisions of the project. The selection of a seed mixture must be approved by the District Storm Water Coordinator and Landscape Architect and shall comply with Standard Specifications Section 20-2.10 and any special provisions for the project. To select the appropriate hydroseeding mixtures, an evaluation of the soil conditions, site topography, season/climate, adjacent environmentally sensitive areas, water availability, maintenance needs, and plans for permanent vegetation is required.

All seeds incorporated in the hydroseed mixture, must comply with the California State Seed Law of the Department of Agriculture. Each seed bag shall be delivered to the site sealed and clearly marked as to species, purity, percent germination, dealer's guarantee, and dates of test. The Contractor shall provide the Resident Engineer with such documentation. The container shall be labeled to clearly reflect the amount of Pure Live Seed contained. All legume seed shall be pellet-inoculated.

Inoculant sources shall be species-specific and shall be applied at a rate of 2 kilograms of inoculant per 100 kilograms of seed (2 pounds inoculant per 100 pounds seed). Refer to Standard Specifications Section 20-2.10.

Commercial fertilizer shall be selected in accordance with Standard Specifications Section 20-2.02 and shall conform to the requirements of the California Food and Agriculture Code.

Soil amendments shall be selected in accordance with the Standard Specifications Section 20-2.03 and shall conform to the requirements of the California Food and Agriculture Code.

Selection of a temporary irrigation system (if necessary) shall be selected in accordance with Standard Specifications Section 20-5.

Prior to the application of hydroseed, the soil surface must be prepared in accordance with Standard Specifications Sections 20-2.01 and 20-3.02. Also, roughen the soil surface with furrows that trend along the contours. Roughening can be done by ripping or sheepsfoot rolling. Track walking is an alternative method of roughening, but should only be used where other methods are impractical.

Hydroseeding can be accomplished using a one-step or multiple-step process; refer to the special provisions for the specified process. When the one-step process is used to apply the mixture of fiber, seed, etc., the seed rate shall be increased to ensure that all seeds have direct contact with the soil. The multiple-step process ensures maximum direct contact of the seeds to soil.

Apply a hydraulic mulch, straw mulch, or wood mulch on top of the hydroseeded area (if necessary) to keep seeds in place and to moderate soil moisture and temperature until the seeds germinate and grow. Refer to Standard Specifications Sections 20-2.06, 20-2.07, 20-2.08 20-2.11, and 20-3.03.

Re-seed, fertilize, mulch, and water during the planting season, using not less than half the original application rates or as needed to maintain coverage and encourage the establishment of vegetation.

If applicable, refer to special provisions of the project or the manufacturer's specifications for exact application rates and drying times of stabilizing emulsions used in conjunction with the hydroseed.

Table 2.2.2-b
Applicability of Hydroseeding (SS-6) to Site Characteristics

Type	*Applied with SS BMPs*	*Flow Conditions*	*Maximum Slope Inclination (V:H)(1)*	*Soil Classification(2)*	*Surface Area*	*Atmospheric Conditions*	*Accessibility*	*Drains to 303(d) Listed Water Body*	*Duration of Need(Y)*
Seed must be approved for site conditions by the Landscape Architect	***Stand alone***	sheet	1:3	SW, SP, SM, SC, ML[Φ], CL[Φ], OL, MH[Φ], CH[Φ], OH, Pt	small to large	A	B	D	Greater than 12 months
	Hydraulic Mulch	sheet	1:2	SW, SP, SM, SC, ML[Φ], CL[Φ], OL, MH[Φ], CH[Φ], OH, Pt	small to large	A	B	C	Greater than 12 months
	Soil Binder	sheet	1:2	SW, SP, SM, SC, ML[Φ], CL[Φ], OL, MH[ΦΣ], CH[ΦΣ], OH[Σ], Pt	small to large	A	B	C	Greater than 12 months
	Straw Mulch Integrated	sheet	1:2	SW, SP, SM, SC, ML[Φ], CL[Φ], OL, MH[Φ], CH[Φ], OH, Pt	small to large	A	B	D	Greater than 12 months
	Straw Mulch and Soil Binder	sheet	1:2	SW, SP, SM, SC, ML[Φ], CL[Φ], OL, MH[Φ], CH[Φ], OH, Pt	small to large	A	B	C,D	Greater than 12 months
	Rolled Erosion Control Products	channelized and sheet	1:1	GM, GC, SW, SP, SM, SC, ML[Φ], CL[Φ], OL, MH[Φ], CH[Φ], OH, Pt	small to medium	A	E	D	Greater than 12 months

(1): Conservative Maximum Slope Inclination (V:H) recommended by Caltrans for product applicability, manufacturer may recommend greater slope inclinations
(2): Refer to Table 2.1-b: Unified Soil Classification System for soil classification descriptions.
A: The BMP cannot be applied during a storm event or freezing conditions. Avoid applying in strong winds and over spraying.
B: The disturbed soil area must be accessible to equipment.
C: If disturbed soil area drains to 303(d) listed water body, potential non-visible pollutant.
D: If disturbed soil area drains to 303(d) listed water body, potential pollutants if breach or malfunction occurs.
Φ: Success of seed germination is limited in soils that have high silt and/or clay due to poor soil permeability.
Σ: Soil with high moisture content may compromise the soil binder's effectiveness and curing time. Hydroseeding with soil binder generally not recommended for theses soils.
(Y): Data obtained from the URS Greiner Woodward Clyde, Soil Stabilization for Temporary Slopes, 1999

Table 2.2.2-c
Time and Cost of Hydroseeding (SS-3)

Applied with SS BMPs	***Delivery Time$_{(Y)}$***	***Installation Time***	***Time Until Effective$_{(Y)}$***	***Cost of Installation$_{(X)}$***	
	days	***hours/hectare***	***days***	***$/hectare***	***$/acre***
Stand Alone	3-14	10 (1)	28	2,150 - 5,360	870 - 2,170
Hydraulic Mulch	3-14	10 (1)	28	5,380 – 8,590	2,170 – 3,470
Soil Binder	3-14	10 (1)	28	3,850 – 9,060	1,570 – 3,670
Straw Mulch	3-14	15 (2)	28	6,600 – 10,560	2,670 – 4,270
Straw Mulch and Soil Binder	3-14	25 (3)	28	8,300 – 14,260	3,370 – 5,770
Rolled Erosion Control Products	3-14	106 (4)	28	16,950 – 141,360	6,870 – 57,170

(1): Assumes a 2 man crew with one 3000 gallon water truck (or access to water) that can cover 2 acres per day. Actual installation time may vary depending on location and field conditions.

(2): Assumes installation of hydroseed is done by a 2 man crew with one 3000 gallon water truck (or access to water) that can cover 2 acres per day. Followed by the application of straw mulch that is bound to the soil by integration (crimped or punched). Also assumes that the straw mulch is applied by a 6 man crew with 2 straw blowers that can cover 4 acres per day. Actual installation time may vary depending on location and field conditions.

(3): Assumes the application (first pass) of the hydroseed is done by a 2 man crew with one 3000 gallon water truck (or access to water) that can cover 2 acres per day. Followed by the application of straw mulch (second pass) that will be bound together by a soil binder. Assumes the straw mulch is applied by a 6 man crew with 2 straw blowers that can cover 4 acres per day. Followed by the application of the soil binder (third pass). Assumes the application of the soil binder is done by a 2 man crew with one 3000 gallon water truck (or access to water) that can cover 2 acres per day. Actual installation time may vary depending on location and field conditions.

(4): Assumes the application of the hydroseed is done by a 2 man crew with one 3000 gallon water truck (or access to water) that can cover 2 acres per day. Assumes the application of the rolled erosion control product is done by a 2 man crew. Actual installation time may vary depending on location and field conditions.

(X): Data obtained from the Caltrans, Erosion Control Manual (Draft), Training Materials, 2003

(Y): Data obtained from the URS Greiner Woodward Clyde, Soil Stabilization for Temporary Slopes, 1999

Description

Soil binders are stabilizing emulsions applied directly to the surface of disturbed soil areas or used as the stabilizing emulsion in hydraulic mulch, hydroseeding, and/or on straw mulch. Soil binders applied directly to the surface temporarily reduce erosion caused by water and wind by penetrating the top soil and binding the soil particles together. Soil binders used as stabilizing emulsions in hydraulic and straw mulches act as the binding agent for the mulch. Depending on the choice, soil binders can be effective for periods of 3 months to 2 years. Soil binders are categorized as:

- Short-lived plant-based materials
- Long-lived plant-based materials
- Polymeric emulsion blends (acrylic polymers)
- Cementitious-based binders

Tackifiers are less durable stabilizing emulsions. Tackifiers are applied directly to the soil surface or used as the stabilizing emulsion in hydraulic and straw mulches for disturbed soil areas that require short term stabilization. Short lived plant based materials and highly diluted polymeric emulsions and cementitious binders are tackifiers.

The more durable stabilizing emulsions are heavy duty soil binders. Heavy duty soil binders are applied directly to the soil surface or used as the stabilizing emulsion in hydraulic and straw mulches for disturbed soil areas that require long term stabilization. Long lived plant based materials and less diluted polymeric emulsions and cementitious binders are heavy duty soil binders.

Table 2.2.3-a: Limitations of Soil Binders

Category	*Limitation*
Selection	• The constituents of some soil binders have the potential to leach out of the soil and/or become slippery during rainy conditions. • Some soil binders require that storm water sampling be performed to determine if the water flowing over or leaching out of the soil binder is contaminated. The Caltrans SWPPP/WPCP Preparation Manual, Pollutant Table, Attachment S, identifies the soil binders that do not require sampling. • Soil binders may not be compatible with certain soils. (e.g., soils primarily consisting of silt of clay or highly compacted soils may not allow the soil binder to penetrate the top soil). • Soil chemistry can limit how effective a soil binder may perform. • Do not apply to areas where the binder would be considered unsuitable with immediate future earthwork and would need to be removed or reapplied. • The site must be accessible to equipment needed to apply soil binders.
Installation	• Low relative humidity can adversely affect the soil binders. • Soil binders cannot be applied when the temperature is below 4ºC (40ºF), in areas where soil is frozen, or when the site experiences freeze and thaw conditions. • The number and frequency of applications may be affected by the surface and subgrade type and conditions, atmospheric conditions, and scheduled maintenance. • Walking, moving equipment, and/or vehicular traffic across areas where a soil binder is applied will damage the BMP by breaking the bonds of the treated top soil. • Care must be taken not to overspray soil binders onto existing vegetation, sidewalks, travel ways, sound walls, and channels.
Flow Conditions	• Soil binders should not be used in areas containing swift-moving concentrated flow or high-volume sheet flow because it has a tendency to be washed away. • When necessary, use with other soil stabilization and sediment control BMPs (see Section 2.3) in order to reduce the slope lengths and limit run-on flows to areas where the soil binder is applied.
Time Until Effective	• Soil binders have minimum drying times, therefore, soil binders cannot be applied immediately before rainfall, during rainfall, and/or where standing water is present.
Duration of Need	• Some soil binders are a short term soil stabilization practice in that they generally last through only a portion of the growing/rainy season.
Maintenance	• Reapplication of soil binders may be necessary to effectively stabilize the soil throughout the season. • Runoff can penetrate a soil binder treated area at the top of the slope, undercut the treated soil and cause spot failures by discharging at a point further down the slope.

Standards and Specifications

The Contractor's soil binder selection must be approved by the Resident Engineer or the District Storm Water Coordinator. A stabilizing emulsion must conform to the Standard Specifications Section 20-2.11.

Consider where the soil binder will be applied when determining if it needs a high resistance to leaching or abrasion, and whether it needs to be compatible with any existing vegetation. Determine the length of time soil stabilization will be needed and if the soil binder will be placed in an area where it will degrade rapidly. In general, slope steepness is not a limiting factor for soil binders, but a higher application rate may be required for steeper slopes. Site-specific soil types will dictate the appropriate soil binders to be used.

Fines and moisture content are key properties of surface materials. Consider a soil binder's ability to penetrate, likelihood of leaching, and ability to form a surface crust on the surface materials.

The frequency of application can be affected by subgrade conditions, surface type, atmospheric conditions, and maintenance schedule. Frequent applications and increased application rates could lead to high costs. Application frequency may be minimized if the soil binder has good penetration, low evaporation, and good longevity. Consider also that frequent application will require frequent equipment cleanup.

A soil binder must be environmentally benign (non-toxic to plant and animal life), easy to apply, easy to maintain, economical, and must not stain paved or painted surfaces. Some soil binders are compatible with existing vegetation. Performance of soil binders depends on temperature, humidity, and traffic across treated areas. Refer to Standard Specifications Section 20-2.11.

Some soil binders are compatible with existing vegetation. Performance of soil binders depends on temperature, humidity, and traffic across treated areas.

Prior to the application of the soil binder, the soil surface must be prepared in accordance with Standard Specifications Sections 20-2.01 and 20-3.02. Also, roughen the soil surface with furrows that trend along the contours. Roughening can be done by ripping or sheepsfoot rolling. Track walking is an alternative method of roughening, but should only be used where other methods are impractical.

Refer to special provisions of the project or the manufacturer's specifications for application rates, pre-wetting needs, equipment cleaning requirements, and curing times (generally 24 hours) of soil binders.

Care must be taken not to overspray soil binders onto existing vegetation, sidewalks, travel ways, sound walls, and any drainage channels.

Depending on the application rate and dilution rate, soil binders can be combined with hydroseeding (see Section 2.2.2 Hydroseeding). A mixture of soil binder, water, seeds, fertilizer and/or straw or wood mulch can be sprayed over an area of disturbed soil to promote plant growth by providing protection and warmth for the seeds.

Soil binders shall not be applied immediately before or during a rain event or where standing water is present.

Table 2.2.3- b: Descriptions of Soil Binders

Category	Type	Description
Plant-Based Material (Short Lived)	***Guar***	• Biodegradable, natural galactomannan-based hydrocolloid, treated with dispersing agents for easy field mixing.
	Starch	• Non-ionic, cold-water soluble (pre-gelatinized) granular cornstarch.
	Psyllium	• Finely ground muciloid coating of plantago seeds that is applied as a dry powder or in a wet slurry to the surface of the soil.
Plant-Based Material (Long Lived)	***Pitch & Rosin Emulsion***	• A non-ionic pitch and rosin emulsion that has a minimum solids content of 48 percent. The rosin shall be a minimum of 26 percent of the total solids content. The soil stabilizer shall be a non-corrosive, water-dilutable emulsion that cures to water-insoluble binding and cementing agent upon application.
Polymeric Emulsion Blends	***Liquid Polymers of Methacrylates & Acrylates***	• A tackifier/sealer that is a liquid polymer of methacrylates and acrylates. It is an aqueous 100 percent acrylic emulsion blend of 40 percent solids by volume that is free from styrene, acetate, vinyl, ethoxylated surfactants, and/or silicates.
	Copolymers of Sodium Acrylates & Acrylamides	• Non-toxic, dry powders that are comprised of copolymers of sodium acrylate and acrylamide.
	Poly-Acrylamides & Copolymer of Acrylamides	• Linear copolymer polyacrylamide is packaged as a dry-flowable solid.
	Hydro-Colloid Polymers	• Various combinations of dry-flowable poly-acrylamides, copolymers, and hydrocolloid polymers.
	Acrylic Copolymers & Polymers	• Liquid or solid polymer or copolymer with an acrylic base that contains a minimum of 55 percent solids. The polymeric compound shall be handled and mixed in a manner that will not cause foaming or shall contain an antifoaming agent. Polymeric soil stabilizer shall be readily miscible in water, non-injurious to seed or animal life, and non-flammable. It shall provide surface soil stabilization for various soil types without totally inhibiting water infiltration, and shall not re-emulsify when cured.
Cementitious-Based Binders	***Gypsum***	• A formulated gypsum-based product that readily mixes with water and mulch to form a thin protective crust on the soil surface. It is composed of highly pure gypsum that is ground, calcined, and processed into calcium sulfate hemihydrate with a minimum purity of 86 percent.

Table 2.2.3-c: Applicability of Soil Binders (SS-5) to Site Characteristics

Type	Class	Flow Conditions	Maximum Slope Inclination (V:H)[1]	Soil Classification[2]	Surface Area	Atmospheric Conditions	Accessibility	Drains to 303(d) Listed Water Body	Duration of Need[Y]
Guar	*Plant-Based Material (Short Lived)*	sheet	1:2	GM[π], GC[π], SW, SP, SM, SC, ML, CL, OL, MH[Σ], CH[Σ], OH[Σ], Pt	medium to large	A	B	C,D	Less than 3 months
Starch		sheet	1:2	GM[π], GC[π], SW, SP, SM, SC, ML, CL, OL, MH[Σ], CH[Σ], OH[Σ], Pt	medium to large	A	B	C,D	Less than 3 months
Psyllium		sheet	1:2	GM[π], GC[π], SW, SP, SM, SC, ML, CL, OL, MH[Σ], CH[Σ], OH[Σ], Pt	medium to large	A	B	C,D	Between 3 and 12 months
Pitch & Rosin Emulsion	*Plant-Based Material (Long Lived)*	sheet	1:2	GM[π], GC[π], SW, SP, SM, SC, ML, CL, OL, MH[Σ], CH[Σ], OH[Σ], Pt	medium to large	A	B	C,D	Between 3 and 12 months
Liquid Polymers of Methacrylates & Acrylates	*Polymeric Emulsion Blends*	sheet	1:2	GM[π], GC[π], SW, SP, SM, SC, ML, CL, OL, MH[Σ], CH[Σ], OH[Σ], Pt	medium to large	A	B	C,D	Less than 3 months
Copolymers of Sodium Acrylates & Acrylamides		sheet	1:2	GM[π], GC[π], SW, SP, SM, SC, ML, CL, OL, MH[Σ], CH[Σ], OH[Σ], Pt	medium to large	A	B	C,D	Less than 3 months
Poly-Acrylamides & Copolymer of Acrylamides		sheet	1:2	GM[π], GC[π], SW, SP, SM, SC, ML, CL, OL, MH[Σ], CH[Σ], OH[Σ], Pt	medium to large	A	B	C,D	Between 3 and 12 months
Hydro-Colloid Polymers		sheet	1:2	GM[π], GC[π], SW, SP, SM, SC, ML, CL, OL, MH[Σ], CH[Σ], OH[Σ], Pt	medium to large	A	B	C,D	Between 3 and 12 months
Acrylic Copolymers & Polymers		sheet	1:2	GM[π], GC[π], SW, SP, SM, SC, ML, CL, OL, MH[Σ], CH[Σ], OH[Σ], Pt	medium to large	A	B	C,D	Greater than 12 months
Gypsum	*Cementitious-Based Binders*	sheet	1:2	GM[π], GC[π], SW, SP, SM, SC, ML, CL, OL, MH[Σ], CH[Σ], OH[Σ], Pt	medium to large	A	B	C,D	Between 3 and 12 months

(1): Conservative Maximum Slope Inclination (V:H) recommended by Caltrans for product applicability, manufacturer may recommend greater slope inclinations
(2): Refer to Table 2.1-b: Unified Soil Classification System for soil classification descriptions.
A: The BMP cannot be applied during a storm event or freezing conditions. Avoid applying in strong winds and over spraying.
B: The disturbed soil area must be accessible to equipment.
C: If disturbed soil area drains to 303(d) listed water body, potential non-visible pollutant.
D: If disturbed soil area drains to 303(d) listed water body, potential pollutants if breach or malfunction occurs.
π: Use of a soil binder in soils with gravel content is less effective as gravel content increases.
Σ: Soil with high moisture content may compromise the soil binder's effectiveness and curing time. Soil Binders are not recommended for theses soils.
(Y): Data obtained from the URS Greiner Woodward Clyde, Soil Stabilization for Temporary Slopes, 1999

Table 2.2.3-d
Mixing/Dilution Rates and Application Rates of Soil Binders

Class	Type	Dilution/Mixing Rate$_{(W)}$		Application Rate$_{(W)}$	
		Metric	SI	Metric	SI
Plant-Based Material (Short Lived)	Guar	1.2-1.8kg/L	1-5 lb/gal	Dependant upon slope inclination See Table 2.2.3-e	
	Starch	A		170 kg/ha	150 lb/ac
	Psyllium	A		90-225 kg/ha	80-200 lb/ac
Plant-Based Material (Long Lived)	Pitch & Rosin Emulsion	Clayey soils1:5 (emulsion: water) Sandy soils 1:10		A	
Polymeric Emulsion Blends	Liquid Polymers of Methacrylates & Acrylates	190L/ha	20 gal/ac	A	
	Copolymers of Sodium Acrylates & Acrylamides	A	A	Dependant upon slope inclination See Table 2.2.3-f	
	Poly-Acrylamides & Copolymer of Acrylamides	1.5 kg/1000L	1 lb/ 100 gal	5.6 kg/ha	5 lb/ac
	Hydro-Colloid Polymers	A		60-70 kg/ha	53-62 lb/ac
	Acrylic Copolymers & Polymers	1:10 (emulsion: water)		11000 L/ha	1175 gal/ac
Cementitious-Based Binders	Gypsum	A		4500-13500 kg/ha	4000-12000 lb/ac

A: Refer to the manufactures specifications or the Projects Special Provisions for dilution/mixing rates or application rates.
(W): Data obtained from Caltrans, Storm Water Quality Handbooks; Construction Site BMP Manual, 2003

Table 2.2.3-e
Application Rates of the Guar Soil Binder Based on Slope Inclination $_{(W)}$

Unit	Slope Inclination (V:H)				
	Flat	1:4	1:3	1:2	1:1
kg/ha	45	50	56	67	78
lb/ac	40	45	50	60	70

(W): Data obtained from Caltrans, Storm Water Quality Handbooks; Construction Site BMP Manual, 2003

Table 2.2.3-f
Application Rates of Copolymers of Sodium Acrylates and Acrylamides Based on Slope Inclination (W)

Unit	Slope Inclination (V:H)		
	Flat to 1:5	1:5 to 1:3	1:2 to 1:1
kg/ha	3.4 - 5.6	5.6 – 11.2	11.2 – 22.4
lb/ac	3.0 – 5.0	5.0 – 10.0	10.0 – 20.0

(W): Data obtained from Caltrans, Storm Water Quality Handbooks; Construction Site BMP Manual, 2003

Table 2.2.3-g
Time and Cost of Soil Binders (SS-5)

Type	Delivery Time(Y)	Installation Time	Time Until Effective (Drying Time)(Y)	Cost of Installation(X)	
	days	hours/hectare	hours	$/hectare	$/acre
Guar	3-7	10(1)	12 - 18	1,700 - 2,200	700 - 900
Starch	3-7	10(1)	9 - 12	1,700 - 2,200	700 - 900
Psyllium	3-7	10(1)	12 – 18	1,700 - 2,200	700 - 900
Pitch & Rosin Emulsion	3-7	10(1)	19 - 24	3,000 - 3,700	1,200 -1,500
Liquid Polymers of Methacrylates & Acrylates	7-14	10(1)	12 - 18	1,700 - 3,700	700 - 1,500
Copolymers of Sodium Acrylates & Acrylamides	7-14	10(1)	12 - 18	1,700 - 3,700	700 - 1,500
Poly-Acrylamides & Copolymer of Acrylamides	7-14	10(1)	4 - 8	1,700 - 3,700	700 - 1,500
Hydro-Colloid Polymers	7-14	10(1)	0 - 4	1,700 - 3,700	700 - 1,500
Acrylic Copolymers & Polymers	3-7	10(1)	36 - 48	1,700 - 3,700	700 - 1,500
Gypsum	3-7	10(1)	4 – 8	2,000 - 3,000	800 - 1,200

(1): Assumes a 2 man crew with one 3000 gallon water truck (or access to water) that can cover 2 acres per day. Actual installation time may vary depending on location and field conditions.
(X): Data obtained from the Caltrans, Erosion Control Manual (Draft), Training Materials, 2003
(Y): Data obtained from the URS Greiner Woodward Clyde, Soil Stabilization for Temporary Slopes, 1999

Description

Straw mulch consists of an applied uniform layer of straw over a disturbed soil area to temporarily stabilize the soil and reduce erosion caused by wind and water. Straw mulch is applied by hand (manual labor) or by mechanical means (straw blower). Methods of securing straw to the soil include:

- Integrated into the soil by crimping, or punching.
- Stabilizing emulsion
- Rolled erosion control product

Table 2.2.4-a: Limitations of Straw Mulch

Category	*Limitation*
Selection	• Due to high demand prior to the rainy season, supplies of straw and/or available erosion control contractors may be limited. This can in turn increase the cost of installation and/or restrict the ability to install straw mulch in a timely manner. • Straw mulch should not be used in areas in which the mulch would be considered unsuitable with immediate future earthwork and would therefore need to be removed or reapplied.
Installation	• Installing straw mulch manually can be physically challenging and time intensive. These factors decrease the ability to easily disperse straw mulch over large areas and limit the amount of surface area that can be covered in a timely, cost effective manner. • Due to the equipment limitations, installing straw mulch with a straw blower requires that the disturbed soil area be within 45 meters (150 feet) [with a hose attachment 90 meters (300 feet)] of a surface or road having the ability to support heavy equipment. • If not anchored correctly to the soil, straw mulch can be blown off by wind or washed away from the disturbed soil areas onto, streets, environmentally sensitive areas, and/or into storm drains. • Care must be taken not to overspray straw mulch onto existing vegetation, sidewalks, travel ways, and channels. • Walking, moving equipment, and/or vehicular traffic across areas where straw mulch is applied can damage the BMP by breaking the bond between soil, straw and if used the stabilizing emulsion, in turn exposing the underlying soil to wind and water.
Flow Conditions	• Straw mulch should not be used in areas containing swift-moving concentrated flows or high-volume sheet flow because it has a tendency to be washed away. • When necessary, use with other soil stabilization and sediment control BMPs (see Section 2.3) to reduce the slope lengths and limit run-on flows to areas where the straw mulch is applied.
Time Until Effective	• If used in conjunction with a soil binders it will have minimum drying times. In this situation, it would not be applied immediately before rainfall, during rainfall, and/or where standing water is present.
Duration of Need	• Straw mulch biodegrades over time and will therefore last foe a moderate length of time.
Maintenance	• Reapplication of straw mulch may be necessary to effectively stabilize the soil throughout the season.

Standards and Specifications

The Contractor's straw mulch selection must be approved by the District Storm Water Coordinator or the Resident Engineer. The straw mulch must be derived from barley, rice, or wheat. All materials used shall conform to Standard Specifications Sections 20-2.06, 20-2.07 and 20-2.11.

Prior to the application of straw mulch, the soil surface must be prepared in accordance with Standard Specifications Sections 20-2.01 and 20-3.02. Also, if a stabilizing emulsion will be used in lieu of incorporation, roughen the soil surface with furrows that trend along the contours. Roughening can be done by ripping or sheepsfoot rolling. Track walking is an alternative method of roughening, but should only be used where other methods are impractical.

Applying and/or incorporating straw mulch shall follow the guidelines in Standard Specifications Section 20-3.03. Applying a stabilizing emulsion shall follow the guidelines in Standard Specifications Section 20-2.11.

When straw mulch is applied to slopes that are unable to support construction equipment, the method of anchoring preferred is a stabilizing emulsion. The selection of stabilizing emulsion shall be based on the ability to hold the fibers in place and the length of time the temporary soil stabilization will be needed. Straw mulch anchored with a stabilizing emulsion must not be applied immediately before or during a rain event or onto standing water.

On slopes stable enough and of sufficient gradient to safely support construction equipment without contributing to compaction and instability problems, straw can be punched into the ground using a knife-blade roller or a straight bladed coulter, or a crimper.

On small areas and/or steep slopes, straw can also be held in place using plastic netting or jute. The netting shall be held in place using 11-gauge wire staples, geotextile pins or wooden stakes. Refer to BMP SS-7, Geotextiles, Plastic Covers, Erosion Control Blankets, and Mats for details about these options. Refer to special provisions of the project or the manufacturer's specifications for more details about rolled erosion control products used in conjunction with the straw mulch.

Care should be taken when applying straw mulch not to place or overspray the straw onto environmentally sensitive areas, existing vegetation, sidewalks, travel ways, and drainage channels.

Application Rate: 4,500 kilograms per hectare (4,100 pounds per acre)

The application rate for straw mulch is constant. This rate will apply an average depth of 25.4 to 38.1 millimeters (1.0 to 1.5 inches) of straw mulch as long as it is evenly distributed over the disturbed soil area.

If used in conjunction with a stabilizing emulsion, refer to special provisions of the project or the manufacturer's specifications for application rates and drying times.

Table 2.2.4-b
Applicability of Straw Mulch (SS-6) to Site Characteristics

Type	*Method of Binding*	*Flow Conditions*	*Maximum Slope Inclination (V:H)$^{(1)}$*	*Soil Classification$^{(2)}$*	*Surface Area*	*Atmospheric Conditions*	*Accessibility*	*Drains to 303(d) Listed Water Body*	*Duration of Need$_{(Y)}$*
Wheat, Rice, or Barley	*Integrated*	sheet	1:2	SW, SP SM, SC, ML, CL, OL, MH, CH, OH, Pt	small to large	A	B	D	Between 3 and 12 months
	Soil Binder	sheet	1:2	SW, SP SM, SC, ML, CL, OL, MH, CH, OH, Pt	small to large	A	B	C,D	Between 3 and 12 months
	Rolled Erosion Control Products	sheet	1:2	SW, SP SM, SC, ML, CL, OL, MH, CH, OH, Pt	small to medium	A	E	D	Between 3 and 12 months

(1): Conservative Maximum Slope Inclination (V:H) recommended by Caltrans for product applicability, manufacturer may recommend greater slope inclinations
(2): Refer to Table 2.1-b: Unified Soil Classification System for soil classification descriptions.
A: The BMP cannot be applied during a storm event or freezing conditions. Avoid applying in strong winds and over spraying.
B: The disturbed soil area must be accessible to equipment.
C: If disturbed soil area drains to 303(d) listed water body, potential non-visible pollutant.
D: If disturbed soil area drains to 303(d) listed water body, potential pollutants if breach or malfunction occurs.
E: The product is applied manually; therefore, road or pad proximity limitations do not affect their applicability.
(Y): Data obtained from the URS Greiner Woodward Clyde, Soil Stabilization for Temporary Slopes, 1999

Table 2.2.4-c
Time and Cost of Straw Mulch (SS-6)

Type	*Method of Binding*	*Delivery Time(Y)*	*Installation Time*	*Time Until Effective*	*Cost of Installation(X)*	
		days	*hours/hectare*	*days*	*$/hectare*	*$/acre*
Wheat, Rice, or Barley	*integrated*	3-5	5(1)	ASAA	4,450 - 5,200	1,800 - 2,100
	soil binder	3-5	15(2)	1 to 2	6,150 – 8,900	2,500 – 3,600
	Rolled Erosion Control Product	3-5	43(3)	ASAA	16,850 – 21,200	6,800 – 8,600

ASAA: The BMP is effective as soon as it is applied.

(1): Assumes a 2 man crew with one 3000 gallon water truck (or access to water) that can cover 2 acres per day. Actual installation time may vary depending on location and field conditions.

(2): Assumes the straw mulch (first pass) is applied by a 6 man crew with 2 straw blowers that can cover 4 acres per day. Followed by the application of the soil binder (second pass). Assumes the application of the soil binder is done by a 2 man crew with one 3000 gallon water truck (or access to water) that can cover 2 acres per day. Actual installation time may vary depending on location and field conditions.

(3): Assumes the straw mulch (first pass) is applied by a 6 man crew with 2 straw blowers that can cover 4 acres per day. Assumes the application of the rolled erosion control product is done by a 2 man crew. Actual installation time may vary depending on location and field conditions.

(X): Data obtained from the Caltrans, Erosion Control Manual (Draft), Training Materials, 2003

(Y): Data obtained from the URS Greiner Woodward Clyde, Soil Stabilization for Temporary Slopes, 1999

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Description

Geotextiles, plastic covers, erosion control blankets, netting, and mats are rolled erosion control BMPs used to protect disturbed soil areas from erosion by water and wind. Rolled erosion control products can be used as stand-alone soil stabilization BMPs, or in conjunction with re-vegetation. Rolled erosion control products can also be used to reinforce (hold in place) mulch. Rolled erosion control products are used in combination with topsoiling, soil amendments, and/or vegetative growth to form a high-strength surface that help protect disturbed soil areas from the erosive forces of water and/or wind and/or the scouring forces of channelized flow.

<u>Geotextiles</u>: Geotextiles are a woven non-biodegradable polypropylene fabric. Woven geotextiles are used on disturbed soil areas where high strength materials are needed to endure abrasive forces through the life of a project. Geotextiles can be used for drainage control and slope stabilization.

<u>Plastic Covers</u>: Plastic covers are impervious, non-biodegradable, plastic sheeting. Plastic covers can be used for drainage control and slope stabilization. Plastic covers are used on stockpiles of soil and/or mulch, and on very small disturbed soil areas that require immediate attention for a short period of time.

<u>Netting</u>: Netting can be composed of a plastic or geotextiles. Plastic netting or mesh is photodegradable geosynthetic materials such as polypropylene, polyethylene, nylon, and/or polyvinyl chloride (PVC). Open weave geotextiles are also considered netting. Netting can be used to secure loose mulches such as straw to the ground.

<u>Erosion Control Blankets</u>: Erosion control blankets can be biodegradable, or biodegradable and photodegradable. Biodegradable blankets are typically composed of fibers such as jute, straw, coconut, or a combination of straw and coconut fibers. The netting, stitching, and/or adhesives that bind an erosion control blanket together must be biodegradable for an erosion control blanket to be 100 percent biodegradable. Biodegradable and photodegradable blankets are composed of biodegradable fibers such as excelsior (curled wood fiber), wood, jute, straw, coconut, or a combination of straw and coconut fibers, and photodegradable polypropylene or polyethylene netting.

Mats: *Mats or Turf Reinforcement Mats (TRMs)* can be biodegradable and photodegradable or non-biodegradable. Biodegradable and photodegradable TRMs are composed of a biodegradable fiber woven together with photodegradable synthetic netting. Non-biodegradable TRMs are composed of interwoven layers of non-biodegradable geosynthetic materials such as polypropylene, nylon, and polyvinyl chloride (PVC) netting. These materials are stitched together to form a three-dimensional matrix that is thick and porous enough to incorporate soil. TRMs are designed to be a more of a permanent form of soil stabilization, but are also suitable for extremely difficult temporary stabilization and high-velocity concentrated flow situations.

Table 2.2.5-a
Limitations of Rolled Erosion Control Products

Category	*Limitation*
Selection	• Rolled erosion control products should not be applied in areas in which it would be considered unsuitable with immediate future earthwork and would need to be removed or reapplied. • Geotextiles and erosion control blankets generally are not suitable for sites that are excessively rocky. Unless combined with topsoiling and/or soil amendments, these products may be unable to maintain complete contact with the soil surface. • Plastic covers are impervious and can cause erosion problems in receiving areas due to the excessive flow with increased velocities. • Plastic covers must only be used as a soil stabilization practice on stockpiles of soil and/or mulch, and on very small disturbed soil areas that require immediate attention for a short period of time. • Geotextiles can be reused if approved by the Resident Engineer. • Wildlife can become entangled in some rolled erosion control products.
Installation	• Installation of rolled erosion control products requires manual labor that can be physically challenging and time intensive. The inability to easily disperse rolled erosion control products over large areas and limit the amount of surface area that can be covered in a timely, cost effective manner. • To be effective, the product must maintain contact with the surface of the disturbed soil area. To ensure this, prior to the application of the BMP, rocks, clogs, sticks, and vegetation must be removed and rills and/or gullies must be filled and compacted. If necessary, topsoiling may be required to properly prepare the soil surface. • Some rolled erosion control products are easily torn and photodegradable. Walking, moving equipment and/or vehicular traffic across areas where these products are applied could damage the BMP. • If not installed correctly: Undercutting could occur at the top of the slope if the BMP is not trenched and anchored correctly. Undermining of the blanket could occur if complete contact with the soil is not maintained. Separation along the vertical and/or horizontal seams could occur due to improper overlap and/or stapling. • If vegetation establishment is used in conjunction with rolled erosion control products and the area is to be mowed at a later date, the anchoring staples, or stake pins must be driven flush to the soil surface to avoid a potential hazard during the mowing.
Flow Conditions	• Because some rolled erosion control products have flow rate limitations not all are suitable for channelized flow. Flow rate limitations and tensile strength must be considered. • When necessary, rolled erosion control products should be used with other soil stabilization and sediment control BMPs (see Section 2.3) to reduce the slope lengths and limit run-on flows to areas where the rolled erosion control products are applied.
Time Until Effective	• Rolled erosion control products are effective as soon as they are applied.
Maintenance	• When damage occurs, reapplication or repair to the damaged areas is necessary to maintain the effectiveness of the BMP.

Standards and Specifications

The selection of the appropriate type of rolled erosion control product must be based on site-specific conditions and applications. The selection made by the Contractor must be approved by the Resident Engineer or the District Storm Water Coordinator. A certification of compliance must be completed in accordance with Standard Specifications Section 6-1.07

Prior to the application of the geotextiles, plastic covers, erosion control blankets, and mats, the soil surface must be prepared in accordance with Standard Specifications Section 20-3.02. To be effective, the product must maintain contact with the surface of the disturbed soil area. To ensure this, prior to the application of the BMP, rocks, clogs, sticks, and vegetation must be removed and rills and/or gullies must be filled and compacted.

Combined with hydroseeding (see Section 2.2.2 Hydroseeding), a mixture of water, seeds, and fertilizer can be sprayed over a disturbed soil area in conjunction with the majority of the rolled erosion control products. Rolled plastic sheeting is not applicable with hydroseeding. Refer to the manufacturers specifications to ensure the rolled erosion control product to be used is compatible with hydroseeding. Most blankets require the application of water, seeds, and fertilizer prior to the application of rolled erosion control products to promote plant growth by providing protection and warmth for the seeds. Some bonded synthetic fiber turf reinforcement mats that are fabricated with spaces to be backfilled with soil may require the application of topsoil, seed, and fertilizer after the application of the rolled erosion control product.

Anchoring rolled erosion control products can be accomplished with U-shaped wire staples, metal geotextile stake pins, and/or triangular wooden stakes. Wire staples and metal stakes shall be driven into the soil until flush with the surface.

All anchors (staples, stakes or pins) shall be:

- 150 millimeters (6 inches) to 450 millimeters (18 inches) in length
- Shall have sufficient penetration into the ground to resist being pulled out.
- Longer anchors may be required for loose soils

Staples (1) for all Rolled Erosion Control Products shall be:

- Made of 3.05 millimeter (0.12 inch) steel wire
- U-shaped with 200 millimeter (8 inch) legs
- 50 millimeter (2 inch) crown.

Metal geotextile stake pins (2) shall be:

- 5 millimeter (0.19 inch) diameter steel
- 40 millimeter (1.5 inch) steel washer at the head of the pin

Blankets (3) shall be furnished in rolled strips

- Minimum width of 2 meters (6.5 feet)
- Minimum length of 25 meters (80 feet)
- Minimum weight of 0.27 kilograms per meters (6.4 pounds per feet squared)

**Table 2.2.5-b:
Descriptions and Specifications of Rolled Erosion Control Products**

Geotextiles (Non-Biodegradable)	

Woven	• Made of woven polypropylene fabric.
	  – Minimum thickness of 1.5 millimeters (0.06 inches)
	  – Minimum width of 3.7 meters (12 feet)
	  – Minimum tensile strength of 0.67 kilo-Newtons (warp) 0.36 kilo-Newtons (fill)
	  – Conformance with ASTM: D4632
	• Permittivity
	  – approximately 0.07 seconds^{-1} in
	  – Conformance with ASTM: D4491
	• Ultraviolet (UV) stability
	  – 70 percent in
	  – Conformance with ASTM: D4355
	• Geotextiles shall be secured in place with wire staples (1) or sandbags and by keying into the tops of slope and edges to prevent infiltration of surface waters under the geotextile.
	• Geotextiles can be re-used if, in the opinion of the Resident Engineer, they are suitable for the use intended.
	• Staples (1) or metal geotextile stake pins (2) shall be used to secure the blanket to the disturbed soil area.

Plastic Covers (Non-Biodegradable)	
Rolled Plastic Sheeting	• Minimum thickness of 6 mil • Keyed in at the top of slope and firmly held in place with sandbags or other weights placed no more than 3 meters (10 feet) apart. • Seams are typically taped or weighted down along their entire length, and there shall be at least a 300 to 600 millimeters (12 to 24 inches) overlap of all seams. • Edges shall be embedded a minimum of 150 millimeters (6 inches) into the soil.
Netting (Non-Biodegradable)	
Plastic Netting	• Lightweight bi-axially-oriented polypropylene polyethylene, nylon, or polyvinyl chloride (PVC) netting. • Designed for securing loose mulches like straw to soil surfaces to establish vegetation. • The netting is photodegradable and is supplied in rolled strips, which shall be secured with U-shaped staples(1) or stakes (2) in accordance with manufacturers' recommendations.
Plastic Mesh	• Open-weave geotextile that is composed of an extruded synthetic fiber woven into a mesh with an opening size of less than 0.5 centimeters (0.2 inches). • It is used with re-vegetation or may be used to secure loose fiber such as straw to the ground. • The material is supplied in rolled strips, which shall be secured to the soil with U-shaped staples (1) or stakes (2) in accordance with manufacturers' recommendations.

(1) (2) (3): See Standards and Specifications of rolled erosion control products for dimensions of the staples, geotextile pins, and blankets.

Table 2.2.5-b (continued): Descriptions and Specifications of Rolled Erosion Control Products

Erosion Control Blankets(Biodegradable)	
Jute	• A natural fiber that is made into a yarn, which is loosely woven into a biodegradable mesh. • Designed to be used in conjunction with vegetation and has lifespan of approximately 1 year. • The material is supplied in rolled strips, which shall be secured to the soil with U-shaped staples or stakes in accordance with manufacturers' recommendations. • Staples (1) shall be used to secure the blanket to the disturbed soil area.
Straw Blanket	• Machine-produced blankets of straw with a lightweight biodegradable netting top layer. • The straw shall be attached to the netting with biodegradable thread or glue strips. • Straw blanket shall be furnished in rolled strips • Staples (1) shall be used to secure the blanket to the disturbed soil area.
Coconut Fiber Blanket (Coir)	• Machine-produced blankets of 100 percent coconut fiber with biodegradable netting on the top and bottom. • The coconut fiber shall be attached to the netting with biodegradable thread or glue strips. • The blanket (3) shall be furnished in rolled strips • Staples (1) shall be used to secure the blanket to the disturbed soil area.
Coconut Fiber Mesh (Coir)	• Thin permeable membranes made from coconut or corn fiber that is spun into a yarn and woven into a biodegradable blanket. • Designed to be used in conjunction with vegetation and typically has lifespan of several years. • The material is supplied in rolled strips, which shall be secured to the soil with U-shaped staples or stakes in accordance with manufacturers' recommendations. • Staples (1) shall be used to secure the blanket to the disturbed soil area.

Straw/Coconut (Coir) Fiber Blanket	• Machine-produced mats.
	  – 70 percent straw and 30 percents coconut fiber
	  – biodegradable netting on the top and bottom net
	• The straw and coconut fiber shall be attached to the netting with biodegradable thread or glue strips.
	• Straw coconut fiber blanket (3) shall be furnished in rolled strips.
	• (1) Staples shall be used to secure the blanket to the disturbed soil area.

(1) (2) (3): See Standards and Specifications of rolled erosion control products for dimensions of the staples, geotextile pins, and blankets.

Table 2.2.5-b (continued): Descriptions and Specifications of Rolled Erosion Control Products

Erosion Control Blankets(Non-Biodegradable)	
Wood Fiber Blanket	• Biodegradable fiber mulch with extruded plastic netting held together with adhesives. • The material is furnished in rolled strips, which shall be secured to the ground with U-shaped staples or stakes in accordance with manufacturers' recommendations. • Staples (1) shall be used to secure the blanket to the disturbed soil area.
Excelsior (Curled Wood Fiber)	• Machine-produced blankets of curled wood excelsior − 80 percent of the fiber 150 millimeters (6 inches) or longer. − Top surface covered with a photodegradable extruded plastic mesh. − Smolder resistant without the use of chemical additives − Non-toxic and non-injurious to plant and animal life • Excelsior blanket shall be furnished in rolled strips, − A minimum width of 1220 millimeters (48 inches) − Average weight of 0.5 kilograms per meter squared (12 pounds per foot squared); ±10 percent, at the time of manufacture. • Staples (1) shall be used to secure the blanket to the disturbed soil area.
Biodegradable Fibers with Synthetic Netting	• Biodegradable fibers, such as wood, straw, and/or coconut fiber, with a light weight polypropylene net stitched to the top and/or stitched to the bottom. • It is furnished in rolled strips, which shall be secured with U-shaped staples or stakes in accordance with manufacturers' recommendations. • Staples (1) shall be used to secure the blanket to the disturbed soil area.
Mats (Non-Biodegradable)	
Biodegradable Fibers with Synthetic Netting	• Biodegradable fibers, such as wood fiber or coconut fiber, with a heavy polypropylene net stitched to the top and a high-strength continuous- filament geo-matrix or net stitched to the bottom. • Staples (1) shall be used to secure the blanket to the disturbed soil area.
Synthetic Fiber with Synthetic Netting	• Turf reinforcement mats composed of durable synthetic fibers treated to resist chemicals and ultraviolet light. • The mat is a dense, 3-dimensional mesh of synthetic (typically polyolefin) fibers stitched between two polypropylene nets. • The mats are designed to be re-vegetated and provide a permanent composite system of soil, roots, and geo-matrix. • The material is furnished in rolled strips, which shall be secured with U-shaped staples or stakes in accordance with manufacturers' recommendations. • Staples (1) shall be used to secure the blanket to the disturbed soil area.
Bonded Synthetic Fibers	• Turf reinforcements mats that consist of a 3-dimensional geo-matrix nylon (or other synthetic) material. • Typically the material has more than 90 percent open area that facilitates root growth. It's tough root-reinforcing system anchors vegetation and protects against hydraulic lift and shear forces created by high volume discharges. • It can be installed over prepared soil, followed by seeding into the mat. • Once vegetated, it becomes an invisible composite system of soil, roots, and geo-matrix. • The material is furnished in rolled strips that shall be secured with U-shaped staples or stakes in accordance with manufacturers' recommendations. • Staples (1) shall be used to secure the blanket to the disturbed soil area.

(1) (2) (3): See Standards and Specifications of rolled erosion control products for dimensions of the staples, geotextile pins, and blankets.

Table 2.2.5-c: Installation on Slopes

Installation of geotextiles, plastic covers, erosion control blankets and mats, on slopes shall be done in accordance with the manufacturers' specifications. General guidelines are as follows:

1. Begin at the top of the slope and anchor the blanket into a trench 150 millimeters deep by 150 millimeters wide (6 inches by 6 inches) by backfilling the trench and compacting the back filled soil by tamping.
2. Unroll the blanket in the down-slope direction. Lay the blanket loosely maintaining direct contact with the soil. Do not stretch the blanket.
3. Overlap the edges of adjacent parallel blankets 50 millimeters (2 inches) to 75 millimeters (3 inches). Staple the blanket's overlapped edges in the down slope direction every 1 meter (3 feet).
4. If the blankets must be spliced (overlapped) wherever one blanket ends and another begins, place the uphill blanket over the top of the downhill blanket with a 150 millimeter (6 inch) overlap. Staple the blanket through the overlapped area approximately every 300 millimeters (12 inches).

Staples must be adequately placed along the edges, down the center, and staggered throughout the blanket to maintain contact with the soil surface.

Slope (V:H)	#staples/m^2	#staples/yd^2
Less than 1:4	2	2
Between 1:4 and 1:2	1.5*	1.5*
Greater than 1:2	1	1

* Also requires 1 staple per meter (1 staple per yard) in the center.

Table 2.2.5-d: Installation in Channels

Installation of geotextiles, erosion control blankets and mats in channels shall be done in accordance with the manufacturer's specifications. General guidelines are as follows:

1. Dig initial anchor trench 300 millimeters (12 inches) deep and 150 millimeters (6 inches) wide across the channel at the lower end of the project area.
2. Excavate intermittent check slots, 150 millimeters (6 inches) deep and 150 millimeters (6 inches) wide across the channel at 8 to 10 meter (25 to 30 foot) intervals along the channels-
3. Cut longitudinal channel anchor slots 100 millimeters (4 inches) deep and 100 millimeters (4 inches) wide along each side of the installation to bury edges of matting, whenever possible extend matting 50 to 75 millimeters (2 to 3 inches) above the crest of the channel side slopes.
4. Beginning at the downstream end and in the center of the channel, place the initial end of the first roll in the anchor trench and secure with fastening devices at 300 millimeter (12 inch) intervals. **Note: matting will initially be upside down in anchor trench**
5. In the same manner, position adjacent rolls in anchor trench, overlapping the preceding roll a minimum of 75 millimeters (3 inches).
6. Secure these initial ends of mats with anchors at 300 millimeter (12 inch) intervals, backfill and compact soil.
7. Unroll center strip of matting upstream. Stop at next check slot or terminal anchor trench. Unroll adjacent mats upstream in similar fashion, maintaining a 75 millimeter (3 inch) overlap.
8. Fold and secure all rolls of matting snugly into all transverse check slots. Lay mat in the bottom of the slot then fold it back against itself. Anchor through both layers of mat at 300 millimeter (12 inch) intervals, then backfill and compact soil. Continue rolling all mat widths upstream to the next check slot or terminal anchor trench.
9. Alternate method for non-critical installations: Place two rows of anchors on 150 millimeter (6 inch) centers at 8 to 10 meter (25 to 30 foot) intervals in lieu of excavated check slots.
10. Shingle-lap spliced ends a minimum of 300 millimeters (12 inches) apart on 300 millimeter (12 inch) intervals.
11. Place edges of outside mats in previously excavated longitudinal slots, anchor using prescribed staple pattern, then backfill and compact the soil.
12. Anchor, fill and compact upstream end of mat in a 300 millimeter (12 inch) by 150millimeter (6 inch) terminal trench.
13. Secure mat to ground surface using U-shaped wire staples, geotextile pins, or wooden stakes.

Table 2.2.5-e: Applicability of Rolled Erosion Control Products (SS-7) to Site Characteristics

BMP Name	Class	Type	Flow Conditions	Maximum Slope Inclination (V:H)(1)	Soil Classification (2)	Surface Area	Atmospheric Conditions	Accessibility	Drains to 303(d) Listed Water Body	Duration of Need(Y)
Geotextiles (3)	Non-Biodegradable	Woven	channelized and/or sheet	1:1	SW, SP, SM,SC, ML, CL, OL, MH, CH	small to medium	all σ	E	D	Between 3 and 12 months
Plastic Covers (3)	Non-Biodegradable	Rolled Plastic Sheeting	channelized and/or sheet	1:1	all	small	all σ	E	D	Between 3 and 12 months
Netting	Photodegradable	Plastic Netting	sheet	1:2	SW, SP, SM,SC, ML, CL, OL, MH, CH	small to medium	all σ	E	D	Between 3 and 12 months
		Plastic Mesh	sheet	1:2	SW, SP, SM,SC, ML, CL, OL, MH, CH	small to medium	all σ	E	D	Greater than 12 months
Erosion Control Blankets	Biodegradable	Jute	sheet	1:2	SW, SP, SM,SC, ML, CL, OL, MH, CH	small to medium	all σ	E	D	Between 3 and 12 months
		Straw Blanket	sheet	1:2	SW, SP, SM,SC, ML, CL, OL, MH, CH	small to medium	all σ	E	D	Between 3 and 12 months
		Coconut Fiber Blanket	sheet	1:1.5	SW, SP, SM,SC, ML, CL, OL, MH, CH	small to medium	all σ	E	D	Greater than 12 months
		Coconut Fiber Mesh	sheet	1:1.5	SW, SP, SM,SC, ML, CL, OL, MH, CH	small to medium	all σ	E	D	Greater than 12 months
		Straw Coconut Fiber Blanket	sheet	1:1.5	SW, SP, SM,SC, ML, CL, OL, MH, CH	small to medium	all σ	E	D	Greater than 12 months
	Biodegradable and Photodegradable	Wood Fiber Blanket	sheet	1:2	SW, SP, SM,SC, ML, CL, OL, MH, CH	small to medium	all σ	E	D	Between 3 and 12 months
		Excelsior (Curled Wood Fiber)	sheet	1:2	SW, SP, SM,SC, ML, CL, OL, MH, CH	small to medium	all σ	E	D	Between 3 and 12 months
		Biodegradable Fibers with Synthetic Netting	sheet	1:1.5	SW, SP, SM,SC, ML, CL, OL, MH, CH	small to medium	all σ	E	D	Greater than 12 months
Mats (4)	Non-Biodegradable	Biodegradable Fibers with Synthetic Netting	channelized and/or sheet	1:1.5	SW, SP, SM,SC, ML, CL, OL, MH, CH	small to medium	all σ	E	D	Greater than 12 months
		Synthetic Fiber with Synthetic Netting	channelized and/or sheet	1:1	SW, SP, SM,SC, ML, CL, OL, MH, CH	small to medium	all σ	E	D	Greater than 12 months
		Bonded Synthetic Fibers	channelized and/or sheet	1:1	SW, SP, SM,SC, ML, CL, OL, MH, CH	small to medium	all σ	E	D	Greater than 12 months

(1): Conservative Maximum Slope Inclination (V:H) recommended by Caltrans for product applicability, manufacturer may recommend greater slope inclinations
(2): Refer to Table 2.1-b: Unified Soil Classification System for soil classification descriptions.
(3): Are not applicable with hydroseeding
(4): Using hydroseed with turf reinforcement mats in channelized flow situations may have limited success due to potentially turbulent flows.
A: The BMP cannot be applied during a storm event or freezing conditions. Avoid applying in strong winds and over spraying.
B: The disturbed soil area must be accessible to equipment.
C: If disturbed soil area drains to 303(d) listed water body, potential non-visible pollutant.
D: If disturbed soil area drains to 303(d) listed water body, potential pollutants if breach or malfunction occurs.
E: The product is applied manually; therefore, road or pad proximity limitations do not affect their applicability.
σ: May be difficult to insert pins into frozen ground.
(Y): Data obtained from the URS Greiner Woodward Clyde, Soil Stabilization for Temporary Slopes, 1999

Table 2.2.5-f: Time and Cost of Rolled Erosion Control Products (SS-7)

BMP Type	Type	Delivery $Time_{(Y)}$	Installation $Time_{(Z)}$	Time Until Effective	Cost of $Installation_{(X)}$	
		days	hours/hectare	days	$/hectare	$/acre
Geotextiles	Woven	3-5	38(1)	ASAA	30,000 - 70,000	12,000 - 28,000
Plastic Covers	Rolled Plastic Sheeting	3-5	38(1)	ASAA	2.00 - 3.00 ($/m^2)	
Netting	Plastic Netting	7-14	38(1)	ASAA	12,400 - 16,000	5,000 - 6,500
	Plastic Mesh	7-14	38(1)	ASAA	7,400 - 8,600	3,000 -3,500
Erosion Control Blankets	Jute	3-5	38(1)	ASAA	14,800 - 17,300	6,000 - 7,000
	Straw Blanket	3-5	38(1)	ASAA	19,800 - 25,900	8,000 - 10,500
	Coconut Fiber Blanket	3-5	38(1)	ASAA	32,000 - 35,000	13,000 - 14,000
	Coconut Fiber Mesh	3-5	38 1)	ASAA	74,000 - 82,000	30,000 - 33,000
	Straw Coconut Fiber Blanket	3-5	38(1)	ASAA	25,000 - 30,000	10,000 - 12,000
	Wood Fiber Blanket	3-5	38(1)	ASAA	19,800 - 25,900	8,000 - 10,500
	Excelsior (Curled Wood Fiber)	3-5	38(1)	ASAA	19,800 - 25,900	8,000 - 10,500
	Biodegradable Fibers with Synthetic Netting	7-14	38(1)	ASAA	74,000 - 89,000	30,000 - 36,000
Mats	Biodegradable Fibers with Synthetic Netting	7-14	96(1)	ASAA	74,000 - 89,000	30,000 - 36,000
	Synthetic Fiber with Synthetic Netting	7-14	96(1)	ASAA	84,000 - 99,000	34,000 - 40,000
	Bonded Synthetic Fibers	7-14	96(1)	ASAA	111,000 - 136,000	45,000 - 55,000

ASAA: The BMP is affective as soon as it is applied.
(1): Assumes that the rolled erosion control product is installed by a 2 man crew.
(X): Data obtained from the Caltrans, Erosion Control Manual (Draft), Training Materials, 2003
(Y): Data obtained from the URS Greiner Woodward Clyde, Soil Stabilization for Temporary Slopes, 1999
(Z): Data obtained from the RS Means, Site work and Landscape Cost Data, 22nd ed. 2003

Description

Wood mulching is the process of applying bark, shredded wood, and/or compost (recycled green material) to bare soil. Primarily for landscaping, wood mulch provides soil stabilization by temporarily reducing the potential for erosion of the underlying soil due to rainfall impact and wind. In addition to soil stabilization, wood mulch increases infiltration, and reduces runoff velocity. When wood mulch is used in conjunction with the vegetation, it helps to hold topsoil, fertilizer, and seed in place. Wood mulching moderates the temperature of the soil, insulates the roots of plants against extreme temperatures, retains moisture, and reduces the need for irrigation. It also reduces the germination of noxious weeds, thus decreasing the need for vegetation control measures. Wood mulch, particularly bark, is suitable around ornamental plantings because it has an attractive appearance.

Compost/Recycled Green Material is a product consisting of chipped and/or shredded ground vegetation, recycled wood or high quality bio-solids that have undergone a thermophilic composting process. The resulting fines are retained as the material is passed through a maximum 9.5 millimeter screen. Compost is produced by recycling vegetation trimmings such as grass, shredded shrubs, and trees. Methods of application are generally by hand, although pneumatic methods are available. It can be used as a temporary ground cover with or without seeding. The green material shall be evenly distributed on site to a depth of not more than 50mm (2in). Compost should not be confused with Composted Mulch, which, are large pieces of composted materials with the fines removed or Shredded Wood/Bark which is chipped wood or bark that has not undergone a thermophilic composting process and does not retain fines.

Shredded Wood/Bark is suitable for ground cover in ornamental or re-vegetated plantings. Shredded wood/bark is distributed by hand although pneumatic methods may be available. The mulch shall be evenly distributed across the soil surface to a depth of 50 to 75 millimeters (2 to 3 inches).

Table 2.2.6-a: Limitations of Wood Mulch

Category	*Limitation*
Selection	• Wood mulches are not suitable for slopes steeper than 1:3 (V:H) because it has a tendency to be moved down steep slopes. Wood mulches are best suited for slopes which are 1:5 (V:H) or flatter. • Wood mulch should not be used in areas where the mulch would be considered unsuitable with immediate future earthwork and would, therefore, need to be removed or reapplied.
Installation	• If not properly prepared, wood mulch (particularly compost) can introduce undesirable vegetation into the underlying soil. • Installing wood mulch using manual labor can be physically challenging and time intensive. These factors decrease the ability to easily disperse wood mulch over large areas and limit the amount of surface area that can be covered in a timely, cost effective manner. • Walking, moving equipment, and/or vehicular traffic across areas where wood mulch is applied can damage the BMP by exposing the underlying soil to wind and water.
Flow Conditions	• Wood mulch should not be used in areas containing swift-moving concentrated flows or high-volume sheet flow because it has a tendency to be washed away (wood is buoyant and may float). • When necessary, it should be used with other soil stabilization and sediment control BMPs (see Section 2.3) to reduce the slope lengths and limit run-on flows to the areas where wood mulch is applied.
Maintenance	• If washed down a slope by sheet flow or concentrated flow, wood mulch can clog storm drain inlets and/or storm drains. • Reapplication of wood mulch may be necessary to effectively stabilize the soil throughout the season. • Wood mulch may need to be removed from or integrated into the disturbed soil before the area can be permanently stabilized.

Standards and Specifications

There are many types of wood mulch, and selection of the appropriate type shall be based on the type of application and site conditions. The District Landscape Architect should approve the use of wood mulches on any project as their use may not be compatible with planned or future projects. The Contractor’s selection of wood mulches shall comply with Standard Specifications Section 20-2.08, and must be approved by the Resident Engineer or the District Storm Water Coordinator.

Prior to the application of the wood mulch, the soil surface must be prepared in accordance with Standard Specifications Sections 20-2.01 and 20-3.02. Also, if required, roughen the soil surface with furrows that trend along the contours. Roughening can be done by ripping or sheepsfoot rolling. Track walking is an alternative method of roughening, but should only be used where other methods are impractical.

All wood mulch must be removed before re-starting work on the slopes.

Table 2.2.6-b
Applicability of Wood Mulch (SS-8) to Site Characteristics

Type	*Flow Conditions*	*Maximum Slope Inclination (V:H)[(1)]*	*Soil Classification[(2)]*	*Surface Area*	*Atmospheric Conditions*	*Accessibility*	*Drains to 303(d) Listed Water Body*	*Duration of Need[(Y)]*
Compost/Recycled Green Material	sheet	1:3	SW, SP, SM, SC, ML, CL, OL, MH, CH, OH, Pt	small	A	B, E	C,D	Between 3 and 12 months
Shredded Wood/Bark	sheet	1:3	SW, SP, SM, SC, ML, CL, OL, MH, CH, OH, Pt	small	A	B, E	C,D	Between 3 and 12 months

(1): Maximum Slope Inclination (V:H) recommended by Caltrans.
(2): Refer to Table 2.1-b: Unified Soil Classification System for soil classification descriptions.
A: The BMP cannot be applied during a storm event or freezing conditions. Avoid applying in strong winds and over spraying.
B: If applied mechanically, the disturbed soil area must be accessible to equipment.
C: If disturbed soil area drains to 303(d) listed water body, potential non-visible pollutant.
D: If disturbed soil area drains to 303(d) listed water body, potential pollutants if breach or malfunction occurs.
E: If applied manually, the road or pad proximity limitations do not affect their applicability.
(Y): Data obtained from the URS Greiner Woodward Clyde, Soil Stabilization for Temporary Slopes, 1999

Table 2.2.6-c
Application Depths of Wood Mulch (SS-8) (W)

Type	*Uniform Depth*	*Slope Inclination*		
		Less than 1:4	*Between1:4 and1:3*	*Greater than 1:3*
Compost/Recycled Green Material	*millimeters*	50.0	50.0	NA
	inches	2.0	2.0	NA
Shredded Wood/Bark	*millimeters*	50.0	75.0	NA
	inches	2.0	3.0	NA

NA: Not Applicable
(W): Data obtained from Caltrans, Storm Water Quality Handbooks; Construction Site BMP Manual, 2003

Table 2.2.6-d
Time and Cost Wood Mulch (SS-8)

Type	*Delivery Time(Y)*	*Installation Time*	*Time Until Effective*	*Cost of Installation(X)*	
	days	*hours/hectare*	*days*	*$/hectare*	*$/acre*
Compost/Recycled Green Material	3-5	320(1)	ASAA	2,220 - 2,960	900 - 1,200
Shredded Wood/Bark	3-5	320(1)	ASAA	11,000 - 22,500	4,000 - 9,000

ASAA: The BMP is affective as soon as it is applied.
(1): Assumes the use of a skid steel loader to apply the mulch, 1 equipment operator, and a 4 man crew to spread the wood mulch. Actual installation time may vary depending on location and field conditions.
(X): Data obtained from the Caltrans, Erosion Control Manual (Draft), Training Materials, 2003
(Y): Data obtained from the URS Greiner Woodward Clyde, Soil Stabilization for Temporary Slopes, 1999

SECTION 2.3
Additional BMPs Used With Temporary Soil Stabilization BMPs

Water pollution control measurements require the use of both temporary soil stabilization and temporary sediment control best management practices. Soil stabilization BMPs are more effective when used in conjunction with sediment control and other soil stabilization BMPs. To properly stabilize slopes and remove sediment from storm water other conditions must be addressed such as, directing and/or slowing concentrated flow, reducing slope lengths, and capturing sediment entrained in storm water. Therefore, it is required that soil stabilization and sediment control BMPs are used in conjunction with each other to comply with the General Construction Permit's rules regarding erosion and sediment control.

Slope inclination and slope length are seen as the most important factors affecting the installation of combined soil stabilization and sediment control BMPs, as these factors have the largest potential impact on erosion rates. A combined increase in slope inclination and slope length will require an increase in the use of soil stabilization and sediment control BMPs.

To limit the erosive effects of storm water flow the slope lengths shall be broken up with sediment control BMPs such as fiber rolls or gravel bags as follows:

- If the slope inclination is 1:4 (V:H) or flatter, break up the slope length with sediment control BMPs at intervals no greater than 6.0 meters.
- If the slope length is between 1:4 (V:H) and 1:2 (V:H), break up the slope length with sediment control BMPs at intervals no greater than 4.5 meters.
- If the slope inclination is 1:2 (V:H) or greater, break up the slope length with sediment control BMPs at intervals no greater than 3.0 meters.

Listed below are the BMPs applied to compliment the soil stabilization BMPs that cover or bind the soil of the disturbed soil areas. The information below also includes a brief explanation of their purpose and applications. Refer to the Storm Water Quality Handbook: Construction Site BMP Manual for details regarding the Limitations, Standards and Specifications, and design of these BMPS. These BMPs are implemented on a project-by-project basis and with other soil stabilization and sediment control BMPs when deemed necessary and determined feasible by the Resident Engineer.

Earth Dikes, Drainage Swales, and Lined Ditches (SS-9)

Earth dikes, drainage swales, and lined ditches, are designed to intercept, concentrate, divert, and convey surface flow away from potentially erodible slopes, as well as, break up slope lengths. These slope stabilization BMPs are used to intercept and divert run-on and runoff flows away from sloped surfaces, directing it toward and/or conveying it down the slope to a stabilized water course, drainage pipe, and/or channel.

Earth dikes, drainage swales, and lined ditches are used at the top of slope to capture and divert run-on flow from adjacent slopes, properties and/or travel ways. These slope stabilization BMPs are used mid-slope to create benches within the slope (breaking up the slope length). These slope stabilization BMPs are also used mid-slope and at the bottom (where runoff concentrates) to intercept, concentrate, divert, and convey sheet flow to a stabilized water course, drainage pipe, and/or channel.

Outlet Protection/Velocity Dissipation Devices (SS-10)

Outlet protection/velocity dissipation devices are designed to reduce the velocity and/or energy of concentrated storm water flows discharging from outlets of pipes, drains, culverts, slope drains, diversion ditches, swales, conduits, lined conveyances and/or channels onto unprotected soil. The reduction in velocity and or energy will limit the amount of soil particles dislodged and transported by the storm water discharging onto the unprotected soil.

These BMPs can be placed in outlets located at the bottom of mild to steep slopes, outlets continuously carrying storm water, or outlets that are subject to short intense storm water flows.

Slope Drains (SS-11)

Slope drains are pipes designed to intercept concentrated surface flows and convey them down a potentially erodible slope into a stabilized water course and/or trapping device.

Silt Fences (SC-1)

Silt fences are temporary linear sediment barriers made of permeable fabric. They are designed to intercept and reduce the velocity of sediment-laden sheet flow allowing the sediment to settle out of the sheet flow before it exits a construction site.

Silt fences are placed down slope of exposed disturbed soil areas below the toe of exposed and/or erodible slopes, around temporary stockpiles, and along streams and channels.

Sediment/Desilting Basins (SC-2)

Sediment/Desilting basins are temporary basins formed by the excavation and/or the construction of an embankment. They are designed to temporarily detain sediment-laden storm water under quiescent conditions allowing sediment to settle out before discharged from the construction site.

Sediment/Desilting basins are recommended for use where sediment-laden water may enter the drainage system or water course. Sediment/Desilting basins may be used on construction projects where the contributing drainage area is between 2 and 4 hectares (5 to 10 acres).

Sediment Traps (SC-3)

Sediment traps are temporary basins with a controlled release structure formed by excavating and/or constructing an earthen embankment across a waterway or low drainage area. They provide additional protection to a water body from sediment-laden storm water by reducing the sediment load before it enters a drainage system or water course.

Sediment traps may be used on construction projects where the contributing drainage area is less than 2 hectares (5 acres). They should be placed where sediment-laden storm water enters a storm drain and/or a water course.

Check Dams (SC-4)

Check dams are small dams constructed of rock, sand bags, or fiber rolls placed in small natural or man-made open channels or drainage ditches. Check dams reduce scour and channel erosion by reducing flow velocities in turn increasing the settlement of sediment.

Check dams are used in small open channels that drain 4 hectares (10 acres) or less, in steep channels where flow velocities exceed 1.5 meters per second (4.9 feet per second), during the establishment of grass linings in drainage ditches and/or channels, and in temporary ditches where the short duration of need does not warrant the establishment of erosion-resistant linings.

Fiber Rolls (SC-5)

Fiber rolls are wood excelsior, rice or wheat straw, or coconut fibers that are rolled and bound into tight tubular rolls. Fiber rolls are placed at regular intervals on the face of slopes and/or at the toe of the slope to intercept runoff, reduce its flow velocity, provide some removal of sediment from the runoff, and release the runoff as sheet flow. Fiber rolls can also e used for inlet protection and check dams under certain conditions.

Fiber rolls are used along the top, face, grade breaks, and toe of slopes to slow the velocity and release as sheet the flow from run-on disturbed soil areas. They are used long the face of slopes to shorten slope lengths. Fiber rolls can be used around the perimeter of a construction projects and down-slope of exposed soil areas. They can also be used around temporary stockpiles. Fiber rolls can be used around drain inlets and as check dams if approved by the Resident Engineer or the District Storm Water Coordinator.

Gravel Bag Berms (SC-6)

Gravel bag berms consist of a single row of gravel bags that are placed end to end to form a barrier across a slope to intercept runoff, reduce its flow velocity, provide some removal of sediment from the runoff, and release the runoff as sheet flow. They can be used in or around areas where flows are moderately concentrated, such as ditches, swales and drain inlets, to divert or detain flows.

Gravel bags should be placed along a level contour with the bags ends tightly abutted not overlapped. Gravel bag berms have many uses. Gravel bags can be used at the top of slope to capture and divert run-on flow from adjacent slopes, properties and/or travel ways. Gravel bag berms can be used on the face, at grade breaks, and o the toe of slopes to shorten slope lengths and release the flow as sheet flow. They can also be used along the perimeter of construction sites and streams and channels. Gravel bag berms can be used down-slope of disturbed soil areas, around stockpiles, and parallel to roadways to keep sediment off pavement. Gravel bag berms can be used to direct flow and create temporary sediment traps. Gravel bag berms can be used across channels to serve as a barrier for utility trenches or to provide a temporary channel crossing for construction equipment. They can be used when construction site sequencing requires adjustments or relocation of barriers to meet the changing needs of the construction site and when the extended construction period limits the use of silt fences or straw bale barriers.

Sand Bag Barriers (SC-8)

Sandbag barriers are temporary linear sediment barriers consisting of stacked sandbags. Sandbag barriers are designed to intercept and slow the velocities of sediment-laden sheet flow run-on and runoff, allowing sediment to settle out and flow to be released as sheet flow.

Sandbag barriers have many uses. Sandbag barriers can be used at the top of slope to capture and divert run-on flow from adjacent slopes, properties and/or travel ways. They can also be used along the perimeter of construction sites and streams and channels. Sandbag barriers can be used down-slope of disturbed soil areas, around stockpiles, and parallel to roadways to keep sediment off pavement. Sandbag barriers can be used to direct flow and create temporary sediment traps. Sandbag barriers can be used across channels to serve as a barrier for utility trenches or to provide a temporary channel crossing for construction equipment. They can be used when construction site sequencing requires adjustments or relocation of barriers to meet the changing needs of the construction site and when the extended construction period limits the use of silt fences or straw bale barriers.

Straw Bale Barrier (SC-9)

Straw bale barriers are temporary linear sediment barriers consisting of straw bales. Straw bale barriers are designed to intercept sediment-laden runoff, reduce its flow velocity, and slow sediment laden sheet flow, allowing sediment to settle out.

Straw bale barriers can be used along the perimeter of construction sites and streams and channels. Straw bale barriers can be used down-slope of disturbed soil areas, around stockpiles, and parallel to roadways to keep sediment off pavement. Straw bale barriers can be used to direct flow and create temporary sediment traps. Straw bale barriers can be used across minor drains or ditches with small contributing drainage areas.

Storm Drain Inlet Protection (SC-10)

Storm drain inlet protection is the use of devices around storm drain inlets to reduce the sediment discharging into the storm drains. These devices detain and/or filter sediment-laden runoff to allow sediment to settle out and/or filter prior to discharging into a drainage system or water course.

Storm drain inlet protection can be used where sediment-laden surface runoff may enter a inlet, disturbed drainage areas have not yet been permanently stabilized, the drainage area is 0.4 hectares (1 acre) or less. Storm drain inlet protection is also appropriate during wet and snow-melt seasons. Storm drain inlet protection cannot be used where ponding will encroach into highway traffic.

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Section 3 is designed to assist the Resident Engineer in understanding storm water monitoring requirements and procedures in order to ensure that the Contractor is properly monitoring the storm water discharges from a construction site to a 303(d) listed water body. This section will assist in developing Storm Water Pollution Prevention Plans (SWPPPs), determining if your existing plan is adequate, as well as assessing the effectiveness of temporary soil stabilization BMPs.

For more guidance on storm water quality monitoring go to:

http://www.dot.ca.gov/hq/construc/stormwater/swppp_training.html

Planning is essential to sample in a way that will meet requirements and provide data that represents the quality of storm water discharging from a construction site. Section 3.1 provides quick step- by-step procedures of how to prepare, conduct, and report storm water monitoring. The steps are organized to guide you through the process from start to finish of storm water sampling. Major topics include:

- Preparing for Sampling
- Conducting Sampling
- Field and Analytical Data Retention

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Preparing for Sampling

Storm water monitoring requires planning for who will perform the laboratory analyses, when, where, and how samples will be collected, and who will conduct the sampling.

Selecting a Laboratory

A laboratory to perform analysis must be selected prior to any sampling being performed. A lab must be able to conduct the necessary analyses. For laboratory analysis, all sampling, sample preservation, and analysis shall be conducted according to test procedures under 40 CFR Part 136. Ensure that the laboratory can perform the following analyses:

- Settleable Solids (ml/L)
- Total Suspended Solids (mg/L)
- Suspended Sediment Concentration according to ASTM D3977-97
- Turbidity (NTU)

Analysis may also include but is not limited to indicator parameters such as pH, specific conductance, dissolved oxygen, conductivity, salinity, and TDS. Make sure to select a laboratory that will provide you with the support that you need, such as, properly cleaned and preserved sampling containers and Chain-of-Custody forms

When to Sample

Sampling is required when through visual inspection, a breach or malfunction in the BMPs results in the discharge of storm water into a 303(d) listed water body. Samples shall be taken during the daylight hours (sunrise to sunset) and during the first two hours of discharge. There must be at least 4 samples taken per month. The storm event must be preceded by at least 24 hours of no measurable precipitation. Have an intensity of at least 0.1 inches of rainfall (depth) of rain in a 24-hour period.

Where to Sample

Sample the 303(d) listed water body upstream and downstream of the construction site discharge. In general, sample away from the bank in or near the main current. Collecting samples directly from ponds, sluggish, or stagnant water should be avoided. Establish sampling locations to determine background, outfall, and downstream water quality conditions. Sites with multiple outfalls or stream crossings may require numerous sampling stations. When setting up sampling stations: Mark all sampling station locations with clearly labeled survey stakes. Photograph each sampling station for future reference and reporting.

How to Sample

Only personnel trained in water quality sampling procedures should collect storm water samples. Necessary supplies can be obtained from a laboratory or a scientific supply catalog. The supplies you will want to have on hand include.

- S Sampling bottles from the lab, including a few extra of each type. When needed, a pole to hold sample bottles and filament strapping tape.

- Powder-free disposable nitrile or latex gloves (sold by medical and laboratory uppliers). Do not use powdered gloves as the powder may contain metals that could contaminate metals samples such as zinc.

- Foul-weather gear

- One or more picnic coolers (depending on the number of samples to be stored and transported or shipped).

- A bound notebook to serve as a field book for keeping records concerning sampling. Notebooks with waterproof pages are available for these field notes at office supply stores. The information to be included in the notes will be described in the “Keeping Records” section of this guide.

- Temperature, pH, and specific conductivity measurements, as an option, can be taken on each sample using hand-held field meters. Operation and maintenance of these meters will follow the manufacturer’s recommendations.

Conducting Sampling

Simple Rules of Sample Collection

- Inform the laboratory when samples will be collected and their expected date and time of arrival. Inform the laboratories of analysis instructions. If meters are not used in the field, inform the laboratory to make pH and conductivity measurements of the composite samples as soon as possible. Inform the laboratory to properly preserve and analyze samples in accordance with the SAP.

- Grab samples with the storm water entering directly into bottles supplied by your lab rather than by transferring the samples from a container that may not be clean.

- Keep samples cooled with ice after collection.

- Record the date, time and location of the sample. Include the project name and contract number.

- Field conditions (weather, temperature, pertinent construction activities, note any prior disturbance of the water body, etc.)

- Complete Chain-of-Custody Forms.

Field and Analytical Data Retention

Develop a relatively small-scale map depicting the project; sampling locations; and major water, land, and road characteristics. All project water quality sampling forms, maps, and pictures of the sampling stations are kept in a single file in the project office for easy access for compliance inspections or peer review of the documentation. Results of field measurements and laboratory analyses must be kept in the SWPPP, which is required to be kept on the project site until the Notice of Termination is filed and approved by the appropriate RWQCB. It is also recommended that training logs, Chain-Of-Custody Forms and other documentation relating to sampling be retained.

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The construction, operation, and maintenance of transportation facilities present a number of unique challenges with respect to preventing erosion and slope instability. These challenges can include bridge drainage, problematic soil types, slope failure, groundwater in mid-slope, and overside drains, down drains, and culverts. All of these require unique temporary and long-term soil stabilization and erosion control solutions to prevent erosion and/or slope stability problems.

This section provides a discussion about each of these challenges, potential erosion and slope stability problems caused by each, and general guidance to evaluate applicable temporary and long-term soil stabilization and erosion control solutions. The selection of the most appropriate solution for a specific site will require the evaluation of site-specific field conditions, such as slope inclination, soil type, and surface area. Therefore, the general guidance provided is intended to be used in conjunction with the site-specific selection resources provided in this manual.

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Slope failure, also referred to as mass wasting, is the down-slope movement of rock debris and soil in response to gravitational stresses. Physical processes of mass wasting result in soil slippage and slides. Slope angle, climate, slope material, and water contribute to the effect of gravity. Water can also increase the driving force by loading, i.e., adding to the total mass that is subjected to the force of gravity. Mass movement occurs much more frequently on steep slopes than on shallow slopes. Shallow soil layers lying on hard, massive or impermeable rocks on steep slopes or resistant flow rocks lying on clay-rich rocks are susceptible to mass movement of soil (Sidle et al., 1985). Such soils may have little attachment to underlying crystalline igneous and metamorphic rocks and thus are subject to debris slides and avalanches.

Debris slides, avalanches, and flows, or combinations thereof, are the most common types of soil mass movement on managed and unmanaged steep (> 25 degree) slopes; these movements occur with high antecedent soil moisture levels and intense high volume rainfall (Sidle et al., 1985).

The orientation of bedding planes, joints, and fractures sometimes determines how the slopes fail. A comprehensive geotechnical survey will determine the approximate orientation of structures in the soil or underlying rock. Landslides usually show signs of instability by slow settlement or the formation of cracks. The structure of the soil and rock formations and the physical properties of the different materials must be established.

Causes of Slope Failure

Slope failure can be caused by:

- Removal of lateral support by, for example, weathering and wetting, land subsidence or faulting, or cutting slopes for roads and other structures.
- Adding weight to slopes by, for example, rain or snow, construction of heavy building and other structures, or water leaking from pipelines or canals.
- Vibrations caused by earthquakes, thunder, or human activities such as heavy machinery, road, and/or air traffic.
- Regional tilting that increases slope angles.
- Decrease of underlying support by subrosion and removal of granular and soluble materials, loss of strength, and/or squeezing out of underlying material.
- Lateral pressure from water in cracks, freezing of water in cracks, hydration of minerals, and mobilization of residual stress.

Measures to Prevent Slope Failure

Minimizing the potential for slope failures requires:

- Identifying slope failure potential areas.
- Preventing slope failures by installing engineering controls:
    - Retaining walls, rock bolts, and "shotcrete" (coating of concrete-rock mixture on slope surface and crevices to prevent water entry) to inhibit slope failure, and
    - Wire cables and wire fences to minimize the danger of rockfalls.
- Controlling drainage by installing interceptor drains to contain runoff and prevent infiltration.
- Reducing slope angle by grading steep slopes into gentler slopes.
- Creating “stair-steps” on very steep slopes.
- Implementing soil stabilization and erosion control measures (see Section 2 and Appendix B for guidance on selecting soil stabilization measures appropriate for site-specific conditions).
- Implementing corrective measures when a landslide occurs, including installing a drainage system to reduce pore pressure in the slope and prevent further movement.

Photograph looking up slope. Erosion damage due to heavy runoff at Bridge abutment.

The design of a structure requires the determination of multiple factors, including, but not limited to, seismic loading, composition and depth of sub-base layers, quality of materials, and construction methods. Guidelines must be adhered to with respect to geometrics, structural sections and drainage requirements. Although design guidelines are available to the engineer, these are not a substitute for engineering knowledge, experience, and judgment.

The following discussions will provide a quick overview of general bridge components and typical conditions that can cause bridge damage (Section 4.2.1), responsibilities for the design and construction of bridge drainage features (Section 4.2.2), and temporary solutions to mitigate drainage, sediment, and erosion problems during the construction process (Section 4.2.3).

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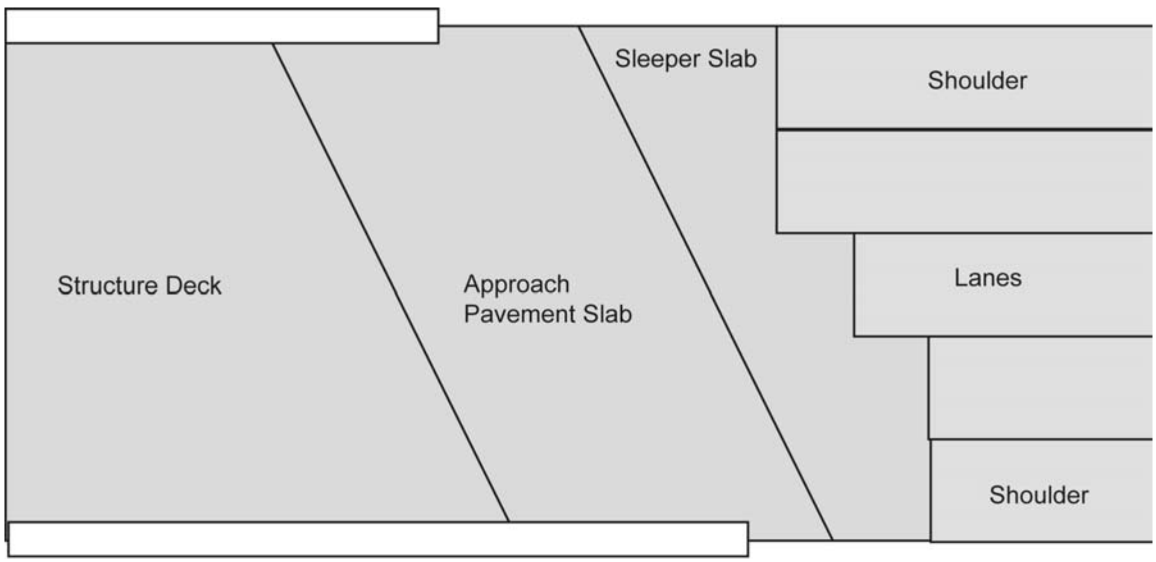
THE BRIDGE

The typical bridge, defined as a structure that spans more than 20 feet over a waterway, is designed to accommodate traffic loading for a specified period of time (20 to 50 years), provide structural integrity, durability, require minimum maintenance and provide for a smooth transition from an earthen embankment and a pavement section to a rigid structure and back.

Typical Bridge Approach (Plan View)



A bridge must be able to sustain seismic loading and must be able to distribute its load through the following components:

1. A roadway embankment – generally an earthen type material that can be considered a yielding medium that is subject to consolidation and settlement;

2. A Structural Sleeper Slab – a reinforced concrete slab that conveys loading to the embankment (minimum length is 15 feet (4.5 m));

3. A Structural Approach Pavement Slab (minimum length is 30 feet (9 m)) that overhangs or cantilevers over the Abutment Wall;

4. An abutment structure, wing walls and footings, that supports the approach slab and its loading; and

5. The Structure Deck.

Extensive research of concrete pavement performance has revealed several detrimental conditions that decrease the life expectancy of the structure.

These conditions are:

- Retention of surface water inflow or saturated soil condition,
- Differential expansion (swelling),
- Frost damage in freeze-thaw areas,
- Poor concrete quality, decrease in strength of concrete,
- Inadequate material or compaction, and
- Dynamic loading by heavy truck axles.

Planning for temporary and permanent drainage from bridge structures must occur during the design phase to avoid erosion of roadway embankments, surfaces around bridge abutments, and bridge end slopes during the construction phase. Planning during the design phase involves coordination between various Caltrans entities and individuals. The coordination required for designing temporary and permanent drainage for roadway embankments, surfaces around bridge abutments, and bridge end slopes is discussed.

The Roadway Embankment

The earthen material at the site must be suitable and must possess sufficient strength to carry the load that will be transferred by the structure. A soils investigation of the roadway prism where the structure will touch down must be carried out by the District Materials Unit. This information is provided to the Office of Structural Foundations (OSF) before a roadway embankment can be constructed. The OSF along with other support offices are responsible for the final analysis and recommendation.

If the material required for the embankment is insufficient or unavailable from the roadway prism, the Designer can specify select material, local borrow, or imported borrow to satisfy the earthen volume required to construct the embankment.

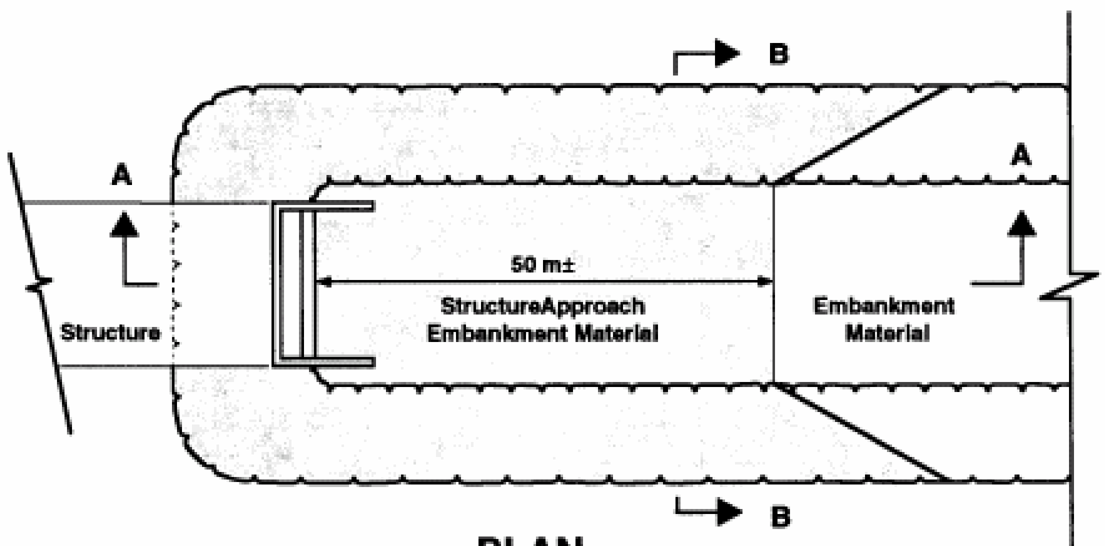
Temporary drainage must be addressed during the design process so that the embankment is not subject to erosion or generate sediment during rainfall events. These features must be coordinated with the OSF and the Department of Structures (DOS).

Bridge Abutments

The Bridge Abutment plays a critical role in the stability of the overall structure. Special attention to the drainage details is necessary to ensure adequate positive drainage to avoid the potential pitfalls encountered with a saturated soil.

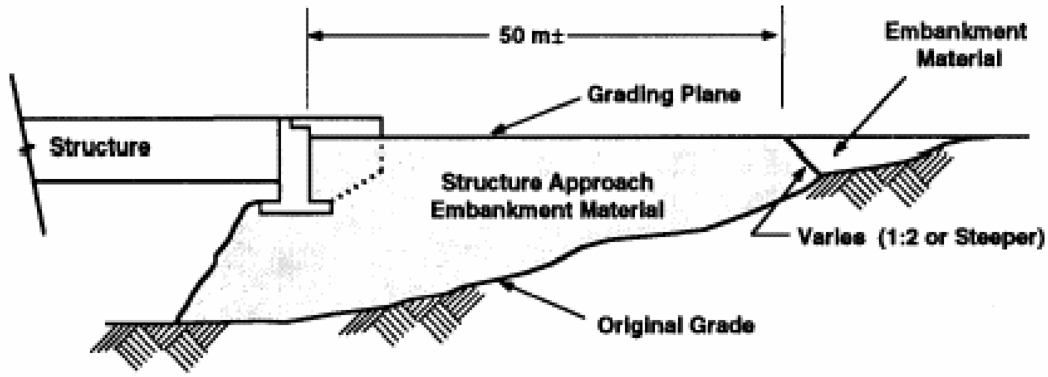
Coordination between the District and the DOS is essential so as to tie in the roadway alignment (vertical and horizontal controls) and all drainage features from the structure. When feasible, temporary drainage features and permanent drainage features should coincide.

The designer or Professional Engineer (PE) is responsible for the Plans, Specifications, and Estimate (PS&E) of the drainage features and structures outside the abutments and wing walls. The PE must ensure that space is provided for drainage connections, pipe extensions are provided whenever feasible, and that all runoff from the abutments and wingwall is adequately controlled or diverted away from the exterior of the structure without causing erosion on the face of the slope.



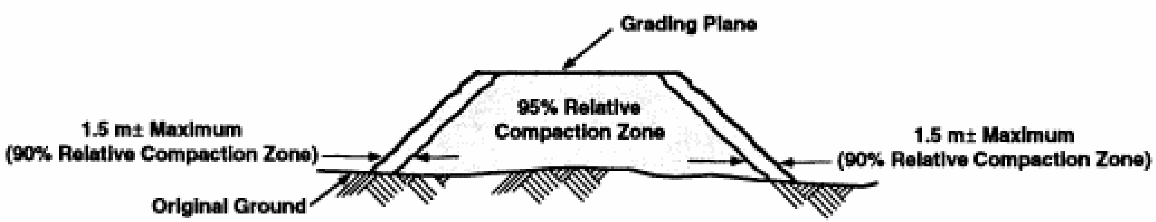
PLAN

The designer or PE is also responsible for the PS&E of all structure approach contract items below the grading plane. These include items such as down drains, overside drains, culvert extensions from the structure, and drainage ditches.



SECTION A-A

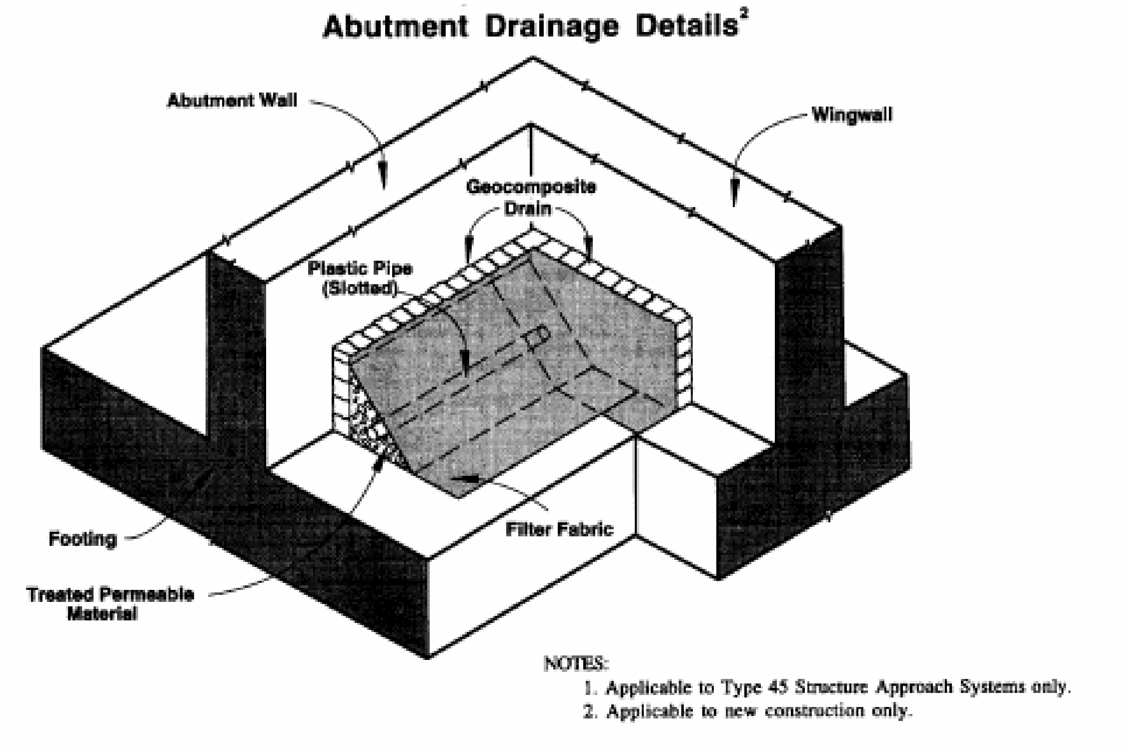
In addition, the PE is responsible for the limits of structure approach embankment material requiring 95% relative compaction as well as the erosion control and maintenance of the slopes surrounding the abutment and wingwalls.



SECTION B-B

The PE is also responsible for coordination, review, and the adequacy of all drainage features outside the structure. The PE must ensure that all connections, ties between the structure approach drainage features and other new or existing drainage facilities can function as intended.

The Department of Structures is responsible for the contiguous drainage system components placed within the abutments and wing walls. DOS is responsible for the PS&E of all structure approach contract items above the grading plane and for the drainage system components placed within the abutments and wingwalls.



The central drainage feature behind the abutment wall and wingwall is made up of a geocomposite drain adjacent to the structure, a slotted or perforated plastic pipe within the structure so as to create positive drainage, a treated permeable material and filter fabric surrounding the drainage system. A pipe outlet system carries the collected water to a location where it will not cause erosion.

Coordination with DOS is necessary for the exit location of the pipe system. The outlet type should be chosen from the standard edge drain outlet types shown in the Standard Plans. The PE must review the drainage design to insure the adequacy of the drainage ties between the abutment and wingwall drainage system and either new or existing drainage facilities.

Slope Treatment

Careful consideration must be given to the protection of bridge end slopes. If high maintenance costs are anticipated, the District will determine where the treatment will be placed and what type of treatment it will use. The following categories are available:

- Slope paving has a high initial cost, and low maintenance cost.

- Landscaped slopes have a medium initial cost, but maintenance will vary with the site.

- Bare slopes have low initial cost, however, maintenance may have the potential to become high.

Regardless of the treatment option chosen, adequate drainage must be provided to reduce or limit the erosion potential and possible saturation of the embankment.

After consultation and determination of appropriate economic and aesthetic factors, the District will submit the Bridge Site Plan Submittal and indicate whether the Division of Structures is to design the slope treatment with the bridge, and include the costs with the structure items, or, the District will design the slope treatment and include the details with the roadway plans.

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Proper drainage must be accounted for during the design of the bridge approach and bridge deck. Drainage discharging from these features may be located along bridge abutments, at the bottom of columns, and along the bridge structure. Erosion control measures must be implemented at these discharge points to prevent the erosion of adjacent slopes.

Permanent Drainage Measures

Bridge Approach

Whenever possible, the roadway surface drainage should be designed for 100% interception so that runoff does not reach the approach slab and sleeper slab. Similarly, the runoff from the structure should be confined to the edge of shoulder or curb and when practicable, should be intercepted before reaching the abutment joint or paving notch. The reason for confinement and 100% interception is to keep water away from the structure approach embankment. Once the surface water is collected, it should be discharged at locations where it will not create erosion. Containment of surface drainage requires special treatment when the approach slab edge extends only to the inside faces of the abutment wingwalls.

When an AC dike is required to protect the side slope from erosion, it should be placed on the approach and sleeper slabs and aligned to tie into the end of the structure railing. The figure below shows the placement of a "Type A" dike with the edge of the barrier controlling runoff and preventing erosion at the edge of the deck.

The guardrail alignment and edge of shoulder govern the positioning of the AC dike. When the Type 45 approach system is used, the AC dike will inevitably crack due to expansion and contraction at the approach/sleeper slab joint. A metal dike insert is used to carry the flow across the sealed joint. The insert acts as a water barrier to minimize erosion of the fill slope.

Details of the metal dike insert are shown in the structure approach plans provided by DOS. Also refer to the HDM Topic 610 for additional information and details regarding joints and seals.

Bridge Deck

The Department of Structures is responsible for all drainage features that have to be incorporated into the bridge deck. It is the responsibility of the roadway designer to request an evaluation and coordination of the deck drain placement.

The deck drains should never be allowed to discharge to traffic that will pass underneath the structure. When feasible, all runoff from the deck drain collection systems should be taken and discharged through a drain outlet at ground elevation where the runoff will not cause or contribute to erosion.

Refer to the Caltrans Standard Plans B7-5, B7-6 and B7-7 for deck drain detail and B7-10 and B7-11 for utility openings details.

Structure and Column Drainage

Although DOS is responsible for utility openings, the District can request additional openings, review and recommend outfall locations along the roadway footprint. Since the District is responsible for drainage features along the roadway prism, existing and proposed drainage features, slopes and elevations, and possible tie-in locations should be provided to DOS. For additional information on utility openings refer to the Caltrans Standard Plans B7-10 and B7-11.

Column drains, designed by DOS, are typically placed down the center of individual columns. However, the placement, orientation and outfall elevation of a column drain are not always accounted for in the design. The district should provide earthwork or finished grade elevations so that DOS can determine the approximate elevation and location of the column drain outfall. For additional information on column drains refer to the Caltrans Standard Plans B7-6 for typical outfall locations and elevations.

Causes of Erosion and Slope Damage

The most common problem encountered around bridge abutments during the winter season is erosion. This can be seen in locations where there is a separation between an impermeable surface such as concrete and a permeable surface such as soil.

Bridge construction is conducted in several stages. However, the big pay items such as form work, steel placement, and concrete work are completed first. Scheduling does not allow for small details like protection at bridge joints, edge drain connections outside the structure and downdrains. These small labor intensive pay items are generally completed after the big pay items are finished. Thus, effort is required to address erosion problems as they occur. The most common reasons for the erosion around the abutments are:

- Roadway connection between dike and barrier not completed,
- Temporary drainage or final drainage not completed,
- Erosion control measures not deployed,
- No drainage features installed at edge of slope treatment.

The figure below shows erosion can occur at the join lines between a non-permeable material (concrete) and a permeable material (soil).

Photograph looking up slope. The beginning of slope erosion and damage adjacent to abutment.

When coordination between departments and/or communication regarding drainage elements falls through the cracks, consequences can be minor to severe. A visual assessment should be conducted during construction and prior to a rainfall event so as to anticipate erosion damage from deck drain discharges during the construction process. In some instances, is likely that the column drains will be operational before the finished grade can be completed around the column footing.

The following figure shows the outfall for a deck drain. No connection has been provided to accommodate the overland flow to reach the concrete lined drainage ditch.

Slope erosion caused by a deck drain that does not reach the concrete lined ditch.

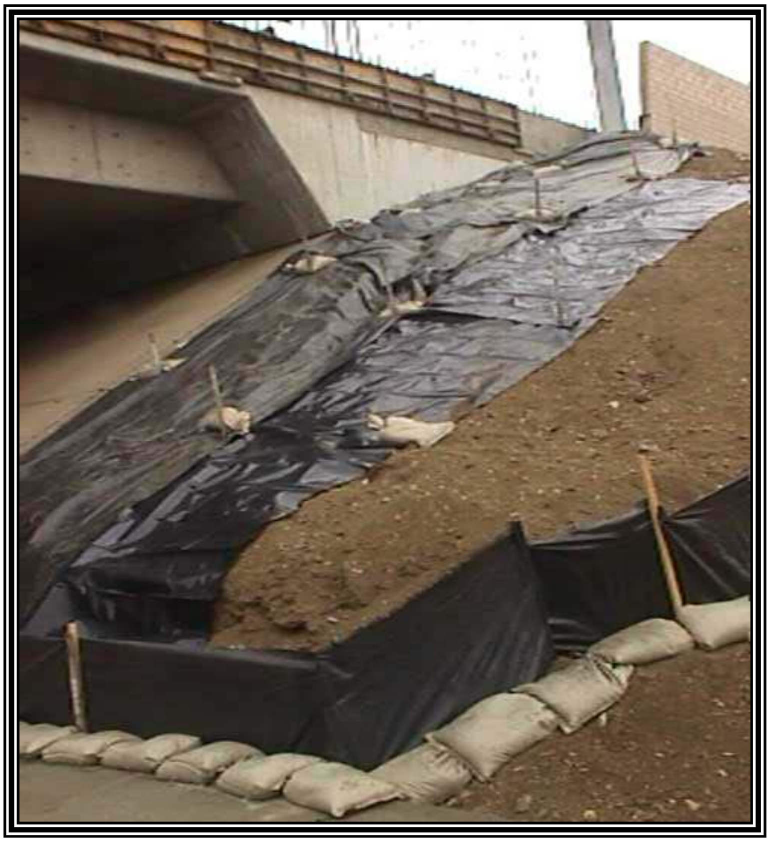
The figure below shows a column drain outfall that has created a flow path at the base of the footing in the direction of a protected inlet. Erosion has occurred because asphalt paving has not been completed between the column and the inlet.

Temporary Repairs

<u>Bridge Drainage</u>

Several temporary erosion control measures can be deployed utilizing readily available materials such as plastic liners (6 mil minimum) and gravel bags to effectively reduce erosion.

As shown in the following figure, a plastic liner and gravel bags serve as temporary repair of slope damage due to erosion at the edge of an abutment apron. This particular low cost fix shows staking of the plastic liner.



Multiple BMP's have been deployed to control slope erosion and damage adjacent to abutment.

A heavy duty Rolled Erosion Control Product such as geotextile blanket can also be deployed to protect the damaged area. Attention to the manufacturers installation procedures will ensure that the slope is protected until a more permanent fix can be implemented. If scheduling and weather permits, slope repair and hydroseeding may be a viable alternative.

Structure and Column Drainage

A field evaluation and visual assessment should be conducted to determine if runoff from the columns will impact the ongoing earthwork or existing subgrade. Care should be taken to divert runoff to a detention pond, when feasible, or other sediment removal device (e.g.: gravel bag chevrons, silt fences) prior to discharge into a drainage inlet.

The figure below shows a temporary solution to reduce erosion by providing 6 mil plastic and gravel bags.

Step by Step Procedures for Temporary Repair

- Conduct a field evaluation and visual assessment to determine if economic impacts are significant,
- Evaluate the condition to determine if runoff will continue to impact the on-going earthwork or existing subgrade,
- Select the proposed temporary repair to reduce further erosion and damage (refer to Section 2 and Appendix B for guidance on selecting measures appropriate for site-specific conditions),
- Install the measure as soon as possible, timing can be critical if adverse weather is expected,
- Formulate a plan and schedule for permanent repair.

Permanent Repairs

As in previous discussions, coordination for the installation of drainage features must take place to insure proper function and protection of structures. The best methods for controlling runoff from a structure are:

- Diverting the runoff to a flat vegetated area off the traveled way,
- Intercepting all runoff through a series of inlets and culverts so as to prevent standing water at the bridge structure,
- Reduction of runoff velocity to prevent erosion at the face of the structure.

Photograph looking up slope. A corrugated metal downdrain has been connected to the deck drain and installed in the slope to control runoff. Rock slope protection provides velocity reduction at the outfall.

Where feasible, runoff can be controlled at the edge of the abutment wall utilizing concrete lined ditches with standard inlets. The runoff velocity must be reduced and sufficient interception capacity must be provided to prevent overspill. Maintenance and a regular inspection schedule at the storm drain inlet will be required. Once again, this must be coordinated with DOS.

Photograph looking down slope. The geometry and depth of the concrete lined ditch must accommodate the runoff expected to prevent overflow.

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Drainage Philosophy

The design of drainage facilities are generally based on engineering, economic and environmental principles. Any one principle should not be addressed without proper investigation of the impacts to the other two. For this reason, good judgment on the utilization of technical principles, economic assessments and environmental impacts must be carefully balanced to arrive at an acceptable solution.

Proper drainage design addresses the removal of runoff from a roadway facility, conveys surface and stream water intercepted upstream to a downstream location, does not create a backwater effect, reduces excessive velocities so as to not cause scour or erosion, and should mimic the natural pre-existing flow conditions where practical.

The objective of properly designed drainage systems and facilities must satisfy the following general categories:

- Traffic safety – removal of runoff from the traveled way to reduce the possibility of ponding and hydroplaning.
- Protection of physical and structural elements of the roadway – the drainage feature must be able to convey runoff without creating excessive headwater, scour or physical damage to the surrounding roadway.
- Passage and removal of runoff (or flood waters), while minimizing damage to private and public facilities – runoff velocities should mimic pre-existing conditions to avoid impacting existing conveyances.
- Accommodation of runoff to outside facilities – drainage design volumes and conveyances should not exceed the capacity of the downstream facility,
- And end treatment requirements – to reduce the potential of sediment transport and erosion damage.

The design of drainage structures and other features must take into account the probability of flooding and level of protection in relation to the importance of the roadway. All these concepts must be addressed so that an economic design that fits the environmental conditions of the site can be achieved.

The Caltrans Highway Design Manual, Chapter 800 – Highway Drainage Design provides references, information, and guidance on approved methods for the design of roadway drainage features, including overside drains, down drains, and culverts.

Overside Drains

The purpose of an overside drain is to remove accumulated runoff from a roadway by conveying the flow down a slope in a controlled manner so as to avoid damage to a roadway slope. The accumulated runoff comes from the roadway, the tops of cuts, or from engineered benches in cut or fill slopes.

Overside drains are typically constructed of asphalt concrete, are placed at the lower end of cut sections to reduce the length of the paved spillway required, and should only be used on slopes that are equal to or flatter than 1:4. Overside drains are an effective temporary measure that allows vegetation to become established on bare slopes. Refer to Chapter 800 – Highway Drainage Design, Topic 834.4 for additional information and guidance for the design of these drainage features. Also refer to the Caltrans Standard Plan D87D for design and installation details.

A drawback to an overside drain is that it may have a shorter life span because it is subjected to the elements. Additionally, the spillway may require velocity dissipation to prevent erosion at the outfall.

Coordination with the placement of the "Type A" dike on the edge of roadway and of the overside drain are critical components to the prevention of overtopping.

Down Drains

Down drains are typically metal pipes that can be adapted to most slope conditions. The preferred fabricated type of down drain is of corrugated metal, although a design modification can be submitted for approval to install plastic corrugated pipe. The purpose of the corrugations within the pipe is to reduce the velocity of runoff conveyed to the outfall. Down drains should be used on slopes equal to or greater than 1:4 and should be anchored when long reaches are installed.

Down drains are a permanent runoff control measures that can be installed aboveground, in rocky terrain conditions, or can be buried in the slope when installed in landscaped areas. In either case, special attention to watertight joints is necessary to prevent leakage and slope erosion.

To improve the life span of corrugated metal, it is recommended that the heavier gage metal be utilized for the fabrication of the pipe. In addition, providing a hot dipped asphalt coating over the fabricated pipe can increase the life span an additional ten years. Refer to Chapter 800 – Highway Drainage Design, Topic 834.4 for additional information and guidance for the design of these drainage features. Also refer to the Caltrans Standard Plan D87A (for corrugated metal pipe), D87B (for corrugated plastic pipe) down drain installation details, D87C for pipe anchor assembly details and D97A through D97G for coupling details.

A drawback to down drains is the high velocities created by the steep slopes and long reaches of pipe. Therefore, velocity dissipation measures must be provided at the outfall to prevent erosion.

Photo looking down slope. View of hot dipped corrugated metal pipe down drain with coupling bands, anchorage assembly and end treatment.

Culvert Drainage

The design of culverts requires the knowledge of hydraulic as well as structural principles. The following elements must be evaluated to appropriately size culverts:

- Frequency and amount of runoff,
- Natural points of concentration and discharge,
- Loading requirements on top of the culvert,
- Effects of corrosive soils on the type of culverts utilized, and
- Velocity dissipation measures required to minimize erosion.

Photo looking upstream. View of multiple corrugated metal pipes with a concrete entrance.

Additional components for culvert design are addressed in the Caltrans Highway Design Manual, Chapter 800 – Highway Drainage Design, Index 801.4.

Culverts are typically constructed of plastic, corrugated metal or concrete. The selection, of appropriate material is based, in part, from recommendations provided in the geotechnical report, field conditions and design experience. Coordination should take place with the Engineering Service Center (ESC) when special drainage problems or unusual drainage designs are required. Additionally, the ESC provides recommendations of structural adequacy of drainage facilities.

Causes of Erosion and Slope Instability

Erosion and instability of slopes adjacent to overside drains, down drains, and culverts may be caused by:

- Improper design and/or construction of drain and/or culvert,
- Damage to drain and/or culvert from storm events that exceeds design parameters,
- Incomplete construction of drain and/or culvert prior to a predicted rainfall event,
- Inadequate velocity dissipation measures at the outfall, and/or
- Inadequate erosion control measures along flow path.

Any one of these conditions can create erosive velocities, sediment displacement around the site, and potential failure of the structure.

Photo looking at storm damage for a temporary haul road.

Temporary Repair Measures

The following steps should be taken to conduct temporary repairs:

- Inspect the damage to the drain, culvert, and/or slope to assess economic impacts,
- Mitigate the loss of sediment and earthen material,
- If a drain was damaged, determine whether reconstruction or partial repair can be accomplished,
- If a drain was damaged, determine if the removal of the drain and abandoning the site is feasible. In certain cases, it may be economical to salvage or relocate the undamaged equipment or material to another location.
- If a culvert requires repair, investigate the economics and feasibility of the following repair options:
  - Abandon, backfill and cap,
  - Excavate repair or replace culvert in place,
  - Insert smaller diameter culvert, or insert sleeve within damaged culvert to maintain flow (note that the structural stability and integrity of the culvert must be determined before a sleeve can be considered), or
  - Armor the entrance and exit of culvert with rock slope protection, concrete headwall or other mechanical device to reduce erosive velocities.

- Coordinate the selection of structural (culvert) repair options with the District and Division of Structures personnel.
- Consider the timing and scheduling of reconstruction - critical if additional adverse weather conditions are anticipated.
- Conduct the repair to the drain or culvert. If required (depends on the depth of cover), replace surrounding earthen material.
- Deploy erosion and sediment control measures around the perimeter of the work taking place.
- Incorporate sediment and erosion control measures to reduce erosion (e.g.: plastic sheeting, gravel bags, and/or silt fence) in the flow path from the outfall and at the inflow to the drain and/or culvert. Follow selection criteria in Appendix B and Section 2.
- Provide velocity dissipation measures to reduce sediment and erosion around the outfall of the drain and/or culvert.
- As time permits, formulate a schedule and plan to install a permanent solution.

Problematic Soil Types

Soil is an aggregate of loose mineral and organic particles that exhibit certain cohesive properties. The basic components are gravel, sand, silt, clay and organic matter. When these basic components are mixed together, they exhibit unique mechanical properties such as strength, plasticity and cohesion. Understanding these properties is key to assessing problematic soil types.

The following soil types have the potential to become unstable and may present erosion and slope stability problems:

- Clay– exhibits plasticity and cohesion
- Silt – exhibits no plasticity or cohesion
- Decomposed Granite – exhibits poor shear strength
- Sand – exhibits high infiltration and poor shear strength.
- Sandstone – exhibits friability.
- Serpentine – exhibits fracture.

Generally, a single soil stabilization product will not be adequate to eliminate erosion in the problematic soil types listed. Sediment control measures should be used in conjunction with other soil stabilization products (for example, erosion control blankets with hydraulic mulch and straw wattles). The following sections summarize each problematic soil type and potential erosion and slope stability problems of each. Emergency, short-term, and long-term soil stabilization measures to prevent erosion and soil stability problems are also discussed for each soil type.

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Un-cemented clayey or silty soils can pose significant problems in terms of slope stability. Clays and silts are the product of weathering processes and are characterized by the fraction of clay and silt-sized grains and the absence of finer binder-type minerals.

Since clays and silts are finer grained than sand, the angle of repose will be less. This means that an un-cemented clay/silty soil will be unstable when material is excavated. The addition of water to silt and clay slopes will also decrease the slope stability.

Emergency and Short-Term Stabilization Measures

For emergency and short-term slope stabilization of clays and silts follow the general guidance listed below:

- Use hydraulic mulch, a bonded fiber matrix, or a chemical soil stabilizer in conjunction with a rolled erosion control product.
- Select appropriate soil stabilization measures based on site-specific conditions and in accordance with the guidance provided in Section 2.
- Use soil stabilization product in conjunction with other sediment control devices and diversionary structures.
- Various methods of compaction can be utilized to help stabilize clays and silts.
- Plastic sheeting and sandbags will help stabilize clays and silts when other soil stabilization products are not available.
- Identify zones where the slope appears to be eroding more quickly and pay special attention to the installation and maintenance of the soil stabilization measures in these zones.
- Pay special attention to wind erosion in clays and silts, but do not apply water, which could cause further erosion of the slope material.

Long Term Stabilization Measures

Long term stabilization of silty and clayey soils should include re-vegetation with plant species suitable for these soil types. A comprehensive soil survey of the slope and grain size analysis should be performed. Select the appropriate plant species and use long-term BMPs like biodegradable erosion control blankets. Consult a landscape architect for details of suitable plant species for the region.

Granite is an igneous rock which is mechanically unstable when exposed to the atmosphere. Granites were formed under high temperatures and pressures with exposures to relatively low levels of oxygen and water as compared to levels in the atmosphere. This instability leads to breakdown of the rock to form sediments or soil.

Decomposed granite soil is a residual soil which has a weakly bonded structure inherited from the parent rock. Granitoid rocks tend to weather to sandy soils as the weathering process destroys the grain-to-grain contact that holds the mineral crystals together. Fractures and joints develop as the rock erodes which accelerates the process of weathering. As granite rock decomposes it becomes what is commonly known as decomposed granite gravel. It is high in trace minerals and environmentally safe. If these soils remain in place long enough, they eventually develop a significant amount of clay. If erosion removes the weathered material at a rapid rate, the resulting soil is coarse-textured and behaves as sand for purposes of slope stability. Many soils with significant clay content have developed from granitoid material. They have greater shear strength and support steeper cut faces than a granitoid-derived soil with little clay.

Emergency and Short-Term Stabilization Measures

For emergency and short-term slope stabilization of weathered granite, follow the general guidance listed below:

- Use hydraulic mulch in conjunction with a rolled erosion control product.
- Select appropriate soil stabilization measures based on site-specific conditions and in accordance with the guidance provided in Section 2.
- Use soil stabilization product in conjunction with other sediment control devices and diversionary structures.
- Plastic sheeting and sandbags will help stabilize weathered granite when other soil stabilization products are not available.
- Identify zones where the slope appears to be eroding more quickly and pay special attention to the installation and maintenance of the soil stabilization measures in these zones.

Long Term Stabilization

Long term stabilization of granitic soils should include re-vegetation with plant species well suited for these soil types. Pine trees and other needle producing varieties are the best choice for stabilizing granitic soils. There are three reasons long-needled pine species, especially ponderosa and Jeffrey pine, are potentially the best choice for many sites. First, they occur naturally on decomposed granitic soils. Second, the long needles form effective mulch which resists wind and downslope movement even on quite steep and exposed road cuts.

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Un-cemented sandy soils can pose significant problems in terms of slope stability and are susceptible to landslides. Sands are the product of weathering processes and are characterized by a fraction of silica-rich sand-sized grains and the absence of finer binder-type minerals.

A sand slope will remain stable at a designated angle of repose. The angle of repose is the maximum angle at which a pile of unconsolidated material can remain stable. Coarser materials will have a higher angle of repose. Finer grain sizes and the addition of water will decrease the angle of repose. This means that adding water to sand slope will cause it to collapse to a lower angle.

Emergency and Short-Term Stabilization Measures

For emergency and short-term slope stabilization of sand slopes, follow the general guidance below:

- Use hydraulic mulch with a bonded fiber matrix or soil binders in conjunction with a rolled erosion control product.
- Select appropriate soil stabilization measures based on site-specific conditions and in accordance with the guidance provided in Section 2.
- If possible, perform a grain size analysis of the sand to estimate the angle of repose. Select BMPs based on a slope angle that is equal to the angle of repose for the slope material.
- Use soil stabilization product in conjunction with other sediment control devices and diversionary structures.

- Plastic sheeting and sandbags will help stabilize sand slopes when other soil stabilization products are not available.
- Identify zones where the slope appears to be eroding more quickly and pay special attention to the installation and maintenance of the soil stabilization measures in these zones.
- Pay special attention to wind erosion in sand slopes, but do not apply water, which could cause further erosion of the slope material.

Long Term Stabilization

Long-term sand stabilization involves using structural controls and native vegetation to stabilize the slope. Planting of grasses, trees, and other ground covers will be adequate for long term stabilization.

Sandstone is a rock composed of sand-sized grains cemented together with other minerals. The cement can be strong or weak, depending on the minerals present. Poorly cemented sandstone will erode quickly and act like a sand for the purposes of slope stability.

Slope stabilization of poorly cemented sandstone involves erosion control blankets, hydraulic mulch, and diversionary structures.

Emergency and Short-Term Stabilization Measures

For emergency and short-term slope stabilization of weathered sandstone slopes that have already eroded and no longer a rock, follow the general guidance below:

- Use hydraulic mulch with a bonded fiber matrix or soil binders in conjunction with a rolled erosion control product.
- Select appropriate soil stabilization measures based on site-specific conditions and in accordance with the guidance provided in Section 2.
- Use soil stabilization product in conjunction with other sediment control devices and diversionary structures.
- Plastic sheeting and sandbags will help stabilize sand slopes when other soil stabilization products are not available.
- Identify zones where the slope appears to be eroding more quickly and pay special attention to the installation and maintenance of the soil stabilization measures in these zones.

Long Term Stabilization

Long-term stabilization of weathered sandstone slopes involves using structural controls and native vegetation to stabilize the slope. Planting of grasses, trees, and other ground covers will be adequate for long-term stabilization.

(Photos courtesy of Terra Firma Geologic Services)

Serpentine soils can be problematic for some sediment control devices. The minerals from which serpentine is formed are highly susceptible to weathering when exposed at the surface due to the low iron oxide content. Once formed, serpentines are susceptible to alteration on exposure to carbon dioxide, a normal component of rainwater which has been absorbed during passage through the atmosphere. Thus the fractured nature of serpentine leads to penetration of water throughout the rock and creation of talc and clay. This process reduces the hardness; causes increased internal fracturing, results in a low water-holding capacity, and increased erodability.

Note that serpentine soils can contain asbestos fibers, which may require certain health and safety precautions.

Emergency and Short-Term Stabilization Measures

For emergency and short-term slope stabilization of serpentine slopes, follow the general guidance below:

- Use hydraulic mulch with a soil binder in conjunction with a rolled erosion control product.
- Use rip-rap or other retaining structures on slopes that have already collapsed.
- Select appropriate soil stabilization measures based on site-specific conditions and in accordance with the guidance provided in Section 2.
- Use soil stabilization product in conjunction with other sediment control devices and diversionary structures.

- Plastic sheeting and sandbags will help stabilize weathered seperntine slopes when other soil stabilization products are not available.
- Identify zones where the slope appears to be eroding more quickly and pay special attention to the installation and maintenance of the soil stabilization measures in these zones.

Long Term Stabilization

Serpentine soils can have toxic levels of nickel and high magnesium to calcium ratio, both of which can be bad for plants. Re-vegetation of serpentine soils could therefore present a problem. Careful selection of appropriate plants is needed to ensure the survivability of the re-instated vegetation. A consultation with a landscape architect is needed if re-vegetation of a serpentine soil is selected as a long term sediment control measure.

Groundwater

Groundwater in mid-slope can sometimes be found perched on an impermeable layer above the groundwater table. Often, this groundwater can be attributed to underground springs that are in the geographic area. Whatever the source, the District should request assistance from the Office of Structural Foundations (OSF) or the Engineering Service Center (ESC).

Refer to the preliminary boring logs from the geotechnical report to assess the water table. If these logs do not provide information on the water table, an additional investigation should be conducted that includes:

- Determining the water table elevation,
- Estimating the depth and extent of the aquifer, and
- Measuring the groundwater discharge.

The information gathered will help evaluate methods or combination of methods to deploy subsurface drain systems in the field. These drain systems can include pipe underdrains, stabilization trenches, and French drains.

Pipe Underdrain

A pipe underdrain system is the primary method to drain groundwater discharges. The typical pipe underdrain system consists of a perforated pipe (200 mm (8 inches)) placed at the bottom of a trench lined with filter fabric and filled with a permeable material that allows water to flow through the void spaces and out the pipe. Filter fabric is required to reduce the migration of fines and sediment through the outlet pipe.

The underdrain can be installed as a single unit along the toe of a cut slope, along the toe of a fill slope, or across the roadway at the downhill end of a cut. Multiple underdrain installations are reserved for areas where stabilization of fill foundation is required. Refer to the Highway Design Manual, Topic 842 for additional information on pipe underdrains.

Stabilization Trenches

Stabilization trenches are utilized when water removal is essential for the stability of foundations. The installation requires trench excavation with equipment that is readily available, lining the trench with filter fabric, placement of permeable material and a perforated pipe at the bottom of the trench so that water can freely exit. End treatment may be required at the outfall to reduce the exit velocity, control sediment, and minimize erosion. The dimensions of the trench (width, depth, and length), along with appropriate design and construction considerations, should be provided in the Geotechnical report. Assistance with the selection of the filter fabric and permeable material specifications should be requested from the Geotechnical Branch of the ESC.

Photo shows stabilizing trench for the removal of groundwater under the roadway.

French Drains

French drains consist of an excavated trench that is backfilled with rock. Although water can initially migrate through the rock voids, fine material carried by the runoff deposits at the outfall may clog and render the culvert ineffective. Therefore, French drains should only be utilized as a temporary, short-term measure.

List of Manufacturers

Manufacturer	Address				Phone	Fax	E-mail
American Excelsior Company	850 Ave H East	Arlington	TX	76011	888-352-9582	888-352-9585	www.curlex.com
Amoco Fabrics and Fiber Company (BP)	260 The Bluffs	Austell	GA	30168	770-944-4579	770-944-4584	www.geotextile.com
Applegate Environmental	1000 Highview Dr	Weberville	MI	48892	517-521-3545	517-521-3597	www.applegate-environmental.com
Applewood Seed Company	5380 Vivian St	Arvada	CO	80002	303-431-7333	303-467-7886	www.applewood.com
Applied Polymer Systems Inc.	519 Industrial Dr	Woodstock	GA	30189	678-494-5998	678-494-5298	www.siltstop.com
Bamert Seed Company	1897 CR 1018	Muleshoe	TX	79347	806-272-5506	806-272-3114	www.bamertseed.com
BBA Nonwovens (Typar Geotextiles)	70 Old Hickory Blvd	Old Hickory	TN	37138	615-847-7132	615-847-7068	www.typargeotextiles.com
Belton Industries	8613 roswell Rd	Atlanta	GA	30350	770-587-0257		www.beltonindustries.com
Bowden's Guaranteed Hydromulch	6516 Colleyville Blvd	Colleyville	TX	76034	817-481-8873	817-481-0218	www.guaranteedhydromulch.com
Bradley Industrial Textiles	PO Box 254	Valparaiso	FL	32580	850-678-6111	850-729-1052	www.bradley-geotextile.com
Buckley Powder Company	42 Inverness Dr E	Englewood	CO	80112	303-790-7008	303-790-7033	www.buckleypowder.com
Burlingham Seeds LLC	8883 Rickreall Rd	Rickreall	OR	97371	503-623-2306	503-623-2477	www.burlinghamseeds.com
Canfor	430 Canfor Ave	New Westminister, BC	CANADA	V3L 5G2	604-520-9327	604-521-3179	www.canfor.com

List of Manufacturers

Manufacturer	Address				Phone	Fax	E-mail
Carthage Mills	4243 Hunt Rd	Cincinnati	OH	45242	513-794-1600	513-794-3434	www.carthagemills.com
Cebeco International Seed Company	PO Box 229	Halsey	OR	97348	541-369-2251	541-369-2640	www.intlseed.com
Central Fiber Corp	4814 Fiber Ln	Wellsville	KS	66092	785-883-4600	785-883-4429	www.centralfiber.com
Chemstar	4707 Waring	Houston	MN	77027	713-355-2356	713-355-2358	www.chemstar.com
Cognis Corp	5051 Estecreek Dr	Cincinnati	OH	45232	513-482-3570	513-482-5512	www.cognis.com
Colbond Geosynthetics	PO Box 1057	Enka	NC	28728	828-665-5050	828-665-5009	www.colbond-usa.com
Colorado Lining International	1062 Singing Hills Rd	Parker	CO	80138	303-841-2022	303-841-5780	www.coloradolining.com
Construction Fabrics and Materials Corporation	2525 Peiper Rd	Cottage Grove	WI	53527	608-839-8031	608-839-4031	www.cfmwi.com
Construction Materials Inc	560 Waconia Ct S.W.	Cedar Rapids	IA	52404	319-366-6446	319-366-1712	cmi66446@aol.com
Dietz Hydroseeding	15745 Kadota St	Sylmar	CA	91342	818-364-7333	818-364-7337	www.dietzhydroseeding.com
Dust Pro Inc	**725 South 12th Place**	**Phoenix,**	**AZ**	**85034**	**602 251-DUST**	**602 251-3659**	**NoDust@dustpro.com**
Earth Saver Erosion Control Products / R.H. Dyck Inc.	PO Box 665	Winters	CA	95694	866-928-8537	530-795-3972	www.earth-savers.com
East Tennessee Geosynthetics	PO Box 12440	Knoxville	TN	37912	865-938-7157	865-938-8455	www.etgeo.com

List of Manufacturers

Manufacturer	Address				Phone	Fax	E-mail
Environmental Products and Applications	73710 Fred Waring Dr #101	Palm Desert	CA	92260	760-779-1814	760-779-1815	www.envirotac.com
Erosion Control Systems	9015 Energy Ln.	Northport	AL	35467	205-333-3080	205-333-3090	www.erosioncontrolsystems.com
Erosion Control Technologies Inc.	PO Box 5383	Branchburg	NJ	08876	908-707-0800	908-707-1445	www.erosioncontroltech.com
Filtrexx	35481 Grafton Eastern	Grafton	OH	44044	440-926-8041	440-926-4021	www.filtrex.com
G.M. BOSTON COMPANY	412 FULLERTON	NEWPORT BEACH	CA	92663	949-722-6799	562-592-0836	www.gmbostoncompany.com
Granite Seed Co	1697 W. 2100 N.	Lehi	UT	84043	801-768-4422		www.graniteseed.com
Green and Bio Tech Inc	1015 Hoyt Ave	Ridgefeild	NJ	07657	201-840-5360	201-840-0996	www.sureturf.com
Greenfix America	6547 Lyerly Rd	Calipatria	CA	92233	800-929-2184	760-348-3097	www.greenfix.com
Hercules Environmental	6596 New Peachtree Rd	Doraville	GA	30340	770-303-0878	770-455-6531	www.herculesenvironmental.com
HMI, Hamilton Manufacturing Inc	901 Russet St	Twin Falls	ID	83301	208-733-9689	208-733-9447	www.hmi-mfg.com
King Fibre Corp	1398 N. Shadeland Ste2224	Indianapolis	IN	46219	317-356-8437	317-356-8421	www.kingfibre.com
LA Chem	2334 W. Directors Row	Salt Lake City	UT	84104	801-975-1770	801-975-7450	www.lachem.com
Layfield Geosythetics	851 Houser Wy N.	Renton	WA	98055	425-254-1075	425-245-1575	www.geomembranes.com

List of Manufacturers

Manufacturer	Address				Phone	Fax	E-mail
Maccaferri Inc	10303 Govenor Lane Blvd	Williamsport	MD	21795	301-223-6910	301-223-4356	www.macceferri-usa.com
Mat Inc	12402 Highway 2	Floodwood	MN	55736	888-477-3028	218-476-2039	www.soilguard.com
Midwest Construction Products	277 N. Collier Blvd	Marco Island	FL	34145	239-642-0556	239-642-6980	www.midwestconstrusct.com
Midwest Industrial Supply	PO Box 8431	Canton	OH	44711	330-456-3121	303-456-3247	www.midwestind.com
Mirafi Construction Products	365 S. Holland Dr	Pendergrass	GA	30567	706-693-2226	706-693-4400	www.mirafi.com
Mulch Manufacturing	6747 Taylor Rd S.W.	Reynoldsburg	OH	43068	904-838-6270	850-973-6679	www.mulchmfg.com
Nedia Enterprises	89-66 217th St.	Jamaica	NY	11427	718-740-5171	718-740-1049	www.nedia.com
North American Green	14649 Hwy 41 N	Evansville	IN	47725	812-867-6632	812-867-0247	www.nagreen.com
Northstar Impex Corporation	12607 Perris Blvd.	Moreno Valley	CA	92553	909-486-0441	909-486-0118	maruti@quik.com
Northwest Linings and Geotextiles	21000 77th Ave S.	Kent	WA	98032	253-872-0244	253-872-0245	www.northwestlinings.com
Pawnee Butte Seed	605 25th St	Greeley	CO	80632	970-356-7002	970-356-7263	www.pawneebuttesseed.com
Profile Products LLC	750 Lake Cook Rd Ste 440	Buffalo Grove	IL	60089	800-726-6371	847-215-0577	www.profileproducts.com
Quattro Environmental	649 “I” Avenue	Coronado	CA	92118	619-522-0044	619-522-0055	www.quattroenvironmental.com

List of Manufacturers

Manufacturer	Address				Phone	Fax	E-mail
Reclamare Co	20727 7th Ave S.	Seattle	WA	98198	206-824-2385	206-824-6798	www.reclamare.com
Reinco Inc	520 North Ave	Plainfield	NJ	07061	908-755-0921	908-755-6379	www.reinco.com
Rolanka Intl Inc	155 Andrew Dr	Stockbridge	GA	30281	770-506-8211	770-506-0391	www.rolanka.com
S&S Seeds	PO Box 1275	Carpinteria	CA	93014	805-684-0436	805-684-2798	www.ssseeds.com
Sacramento Bag Co	530 Q St	Sacramento	CA	95812	916-441-6121	916-441-7860	www.sacbag.com
SI Geosolutions	4019 Industry Dr	Chattanooga	TN	37416	423-892-8080	423-894-6761	www.fixsoil.com
Stover Seed Co	1415 E. 6th St	Los Angeles	CA	90002	213-626-9668	213-626-4920	www.stoverseed.com
Synteen USA	12310 Province Town Dr	Charlotte	NC	28277	803-416-8336	803-416-8344	www.synteen.com
Terra Novo	14716 Harvest Crest	Bakersfield	CA	93312	661-392-9771	661-392-1230	www.terranovo.com
TrapMaster	809 Broad St	Wrens	GA	30833	636-273-9280		www.trapmasterproducts.com
TurfMaker Corp	4931 Grisham Dr	Rowlett	TX	75088	800-551-2304	972-463-2576	www.turfmaker.com
Turf-Seed Inc	PO Box 250	Hubbard	OR	97032	503-651-2130	503-651-2351	www.turf-seed.com
United States Gypsum Company	125 South Franklin Street	Chicago	IL	60606	800-487-4431		www.gypsumsolutions.com

List of Manufacturers

Manufacturer	Address				Phone	Fax	E-mail
Webtec Inc	PO Box 19729	Charlotte	NC	28219	704-398-0954	704-394-7946	www.webtecgeos.com
Wind River Seed	3075 Lane 51 1/2	Manderson	WY	82432	307-568-3361	307-568-3364	www.windriverseed.com

APPENDIX A
Manufacturer and Distributor Information

Manufacturer	SS-3 Hydraulic Mulch	SS-4 Hydroseeding	SS-5 Soil Binders	SS-6 Straw Mulch	SS-7 Rolled Erosion Control	SS-8 Wood Mulch
American Excelsior Company	•		•		•	
Amoco Fabrics and fiber Company					•	
Applegate Environmental	•	•				
Applewood Seed Company		•				
Applied Polymer Systems Inc.			•			
Bamert Seed Company		•				
BBA Nonwovens (Typar Geotextiles)					•	
Belton Industries					•	
Bowden's Guaranteed Hydromulch Inc.	•	•				
Bradley Industrial Textiles					•	
Buckley Powder Company	•		•		•	
Burlingham Seeds LLC		•				
Canfor	•		•			
Carthage Mills					•	
Cebeco International Seed Company		•				
Central Fiber Corp	•					
Chemstar			•			
Cognis Corp			•			
Colbond Geosynthetics					•	
Colorado Lining International					•	
Construction Fabrics and Materials Corporation	•		•		•	
Construction Materials Inc					•	
Dust Pro Inc.			•			
Dietz Hydroseeding		•				
Earthsaver Erosion Control Products R.H Dyck Inc						
East Tennessee Geosynthetics					•	
Environmental Products and Applications	•	•	•		•	
Erosion Control Systems					•	
Erosion Control Technologies Inc.			•			
Filtrexx					•	
G.M. Boston Co			•			
Granite Seed Co	•	•	•		•	
Green and Bio Tech Inc					•	
Greenfix Amaerica					•	
Hercules Environmental			•			
Hamilton Manufacturing Inc	•	•	•	•		•
King Fibre Corp					•	
LA Chem			•			
Layfield Geosythetics			•		•	
Maccaferri Inc					•	
Mat Inc	•		•	•	•	•
Midwest Construction Products	•	•	•	•	•	•
Midwest Industrial Supply		•	•			
Mirafi Construction Products					•	
Mulch Manufacturing				•		•
Nedia Enterprises	•	•	•	•	•	•
North American Green	•	•	•		•	
Northwest Linings and Geotextiles	•	•	•		•	
Pawnee Butte Seed	•	•	•			
Profile Products LLC	•		•			
Quattro Environmental	•		•			
Reclamare Co		•	•			
Reinco Inc	•	•	•			
Rolanka Intl Inc	•	•	•	•	•	•
S&S Seeds		•			•	
Sacramento Bag Company					•	
SI Geosolutions					•	
Stover Seed Co		•				
Synteen USA					•	
Ten Cate Nicolon					•	
Terra Novo	•		•			
TrapMaster					•	
TurfMaker Corp		•				
Turf-Seed Inc		•				
United Gypsum Company			•			
Webtec Inc					•	
Wind River Seed		•				

List of Distributors

Distributor	Contact	Address				Phone Number	Fax
Acme Bag Company	Stephen Short	2528 Main Street, Ste. A	Chula Vista	CA	91911	800-275-2263	619-429-0969
Agri Pacific, Inc.		9960 Indiana Avenue, Suite 12	Riverside	CA	92503		909-343-2110
Agrono-Tec Seed Co.						909-674-0638	
ATCO Construction Products	Tom Tubbs	4025 Nelson Ave.	Concord	CA	94520	925-686-4430	925-825-1397
ATCO Construction Products	Mike Marhenke	4025 Nelson Ave.	Concord	CA	94520	925-686-4430	925-825-1397
Baron Bag Company	Larry Gould	2816 East 54th Street	Vernon	CA	90058	800-562-6055	323-588-1815
California Paving Fabrics	Wendel Benson	2300 Barney Street	Anderson	CA	96007	800-443-6322	530-365-0100
Central Garden Supply	Sonny Murphy	3620 Happy Valley Road	Lafayette	CA	94549	800-535-3100	925-283-6165
Continental Western		P.O. Box 26636	San Diego	CA	92196	858-268-1151	
Contractors Pipe	Ray Lohmier	5242 Andrew Drive	La Palma	CA	90623	714-670-7811	
Contractors Pipe	Dave McInroe	4036 Alto Street	Oceanside	CA	92056	760-724-4369	
Ewing Irrigation			El Cajon	CA		619-562-3300	
Ewing Irrigation			Loomis			916-652-9530	
Ewing Irrigation			Vacaville			707-448-9530	
Geo Options, Inc.	Rich Gubera	888 Howe Road	Martinez	CA	94553	925-335-9220	925-335-9229

List of Distributors

Distributor	Contact	Address				Phone Number	Fax
Greenfix America, LLC	Mark Kimberlin	6547 Lyerly Road	Calipatria	CA	92233	800-929-2184	760-348-3097
Golden Gate Products		P.O. Box 106	Davis	CA	95617	707-678-6798	
Hayward Lumber	John Knight	10 Ragsdale Drive, Suite 100	Monterey	CA	93940	831-643-1900	831-644-7610
Hayward Lumber	Harold Sims	429 Front Street	Salinas	CA	93901	800-640-1959	831-755-8821
Hayward Lumber	Manuel Jimenez,Jr.	1140 Sunset Drive	Pacific Grove	CA	93950	831-373-1326	831-646-1872
Hayward Lumber	Darrell Dillard	944 Pine Street	Paso Robles	CA	93446	805-238-4900	805-238-0376
Hayward Lumber	Thomas Cerny	236 Higuera Street	San Luis Obispo	CA	93401	805-543-0825	805-543-0756
Hayward Lumber	Bill Bumpus	800 West Betteravia Road	Santa Maria	CA	93455	805-928-8557	805-928-3439
Hayward Lumber	Mark Mei	79 Frederick Lopez Road	Goleta	CA	93117	805-964-7711	805-967-9649
Horizon	Eric Grady	301 Broadway	Sacramento	CA	95818-2039	800-510-6163	800-510-6167
Horizon	Brandon Baudot	301 Broadway	Sacramento	CA	95818-2039	916-492-1000	916-492-1057
Horizon	Pete Shaw	861 Galleria Blvd.	Roseville	CA	95678	916-780-2033	916-780-2034
Horizon	Larry Rossetti	1880 Arnold Industrial Place	Concord	CA	94520	925-825-3344	925-798-9436
Horizon	Leeanna Schoedar	7144 Regional Street	Dublin	CA	94568-2324	925-551-8383	925-551-5968
Horizon	James Neufield	349 West Bedford	Fresno	CA	93711-6050	559-431-8007	559-431-2714

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Distributor	Contact	Address				Phone Number	Fax
Horizon	Mostafa Yusuf	4060 Campbell Ave.	Menlo Park	CA	94025-1088	650-323-5161	650-323-2011
Horizon	Jesus Arteaga	3065 N. HWY 59	Merced	CA	95340	209-383-3330	209-383-0770
Horizon	Jennifer Jaggers	3229 California Blvd.	Napa	CA	94558-3309	707-255-7575	707-258-0401
Horizon	Jose Banelos	1990 Stone Ave.	San Jose	CA	95125-1314	408-287-7882	408-287-1336
Horizon	Juan Amador	63 Lakspur	San Rafael	CA	94901-4820	415-454-4313	415-456-4238
Horizon	Mike Renfor	238 Todd Road	Santa Rosa	CA	95407-8103	707-584-7272	707-584-5590
Horizon	John Williams	3355 N. Ad Art Road	Stockton	CA	95215	209-931-8555	209-931-6539
Horizon	Chris Keenen	1232 Callen Street	Vacaville	CA	95688-3002	707-447-7773	707-448-7542
Horizon	Harvey Stanger	1990 Stone Ave.	San Jose	CA	95125-1314	408-971-9500	408-287-4614
Horizon Distribution Center	Roger Rodriguez	1521 South Fresno Ave.	Stockton	CA	95206	209-460-1703	209-460-1712
Huttig Building Prod.	Alan Coppin	8435 24th Avenue	Sacramento	CA	95826	800-952-8614	916-381-2834
Hydro-Scape Products, Inc.	Tony Kennerly	5895 Kearny Villa Road	San Diego	CA	92123-1172	858-560-6611	858-571-6514
Hydro-Scape Products, Inc.	Jaime Barraza	9546 Commerce Center Drive	Rancho Cucamonga	CA	91730	909-980-5353	909-944-5078
Hydro-Scape Products, Inc.	Tom Wilk	41581 Enterprise Circle North	Temecula	CA	92590	909-296-9898	909-296-6520
Hydro-Scape Products, Inc.	Steve Fry	610 N. Batavia	Orange	CA	92868	714-639-1850	714-744-4314

List of Distributors

Distributor	Contact	Address				Phone Number	Fax
Hydro-Scape Products, Inc.	Dean Hardie	360 East Harrison Street	Corona	CA	92879	909-734-3330	909-272-8572
Hydro-Scape Products, Inc.	Luke Hardesty	77-868 Wildcat Drive	Palm Desert	CA	92211	760-360-2950	760-360-5921
Hydro-Scape Products, Inc.	Ralph Tomaselli	1548 Mountain View Ave.	San Bernardino	CA	92408	909-824-3612	909-796-6399
Hydro-Scape Products, Inc.	Raymond Ruan	375 Trousdale Drive	Chula Vista	CA	91910	619-691-9700	619-426-3397
Hydro-Scape Products, Inc.	John White	624 Maulhardt Ave.	Oxnard	CA	93030	805-983-8440	805-983-8390
Hydro-Scape Products, Inc.	Barry Beiswenger	5701 El Camino Real	Carlsbad	CA	92008	760-438-7661	760-438-0179
Hydro-Scape Products, Inc.	Bob Frankhauser	33012 Calle Aviador	San Juan Capistrano	CA	92675	949-496-1998	949-496-0646
Hydro-Scape Products, Inc.	Mike Mercurio	435 N. Marshall Ave.	El Cajon	CA	92020	619-440-4703	
Hydro-Scape Products, Inc.	Eric Kline	731 Enterprise Street	Escondido	CA	92029	760-746-8000	760-746-5369
Hydro-Scape Products, Inc.	Don Almack	750 South Coast Hwy 101	Encinitas	CA	92024	760-436-2062	760-942-6473
Hydro-Scape Products, Inc.	Chris Spencer	16025 Robin Way	City of Industry	CA	91745	626-968-0047	626-968-0616
Hydro-Scape Products, Inc.	Chad Darling	22427 Market Street	Newhall	CA	91321	661-291-1588	661-291-1762
Hydro-Scape Products, Inc.	Greg Holloway	22542 Shannon Circle	Lake Forest	CA	92630	949-951-8827	949-837-8534
Hydro-Scape Products, Inc.	Al Zamudio	8103 Canoga Ave.	Canoga Park	CA	91304	818-712-0050	818-340-7789
John Shelton, Inc.	Jim Pozzi	9860 Monterey Road	Morgan Hill	CA	95037	408-463-0800	

List of Distributors

Distributor	Contact	Address				Phone Number	Fax
John Towns & Associates	John Towns	30 Railroad Ave., Suite 1	Point Richmond	CA	94801	501-233-7100	510-233-7277
J.S. Bechtold Company	Julie Bechtold	9729 Indiana Creek Way	Escondido	CA	92026	877-751-8972	760-751-2686
Kalmia Sales						909-698-9919	
LESCO, Inc.		1111 N. Tustin Ave	Anaheim	CA	92807	714-632-1130	
LESCO, Inc.		11415 Sunrise Gold Circle, Suites 11 & 12	Rancho Cordova	CA		916-852-6483	
LESCO, Inc.		75220 Merle Drive	Palm Desert	CA	92211	760-341-3221	
LESCO, Inc.		890 Service Street, Unit E	San Jose	CA	95112	408-436-1745	
LESCO, Inc.		15885 Sprague Road	Strongsville	OH	44136	800-321-5325	800-673-3030
Linwood Supply		P.O. Box 463	Dixon	CA	95620	707-678-5087	
Pacific Soil Stabilization	Bill Saladin	1279 West Stowell Road, Unit A	Santa Maria	CA	93454	800-473-1965	805-925-4787
Reed & Graham, Inc.	Tim Kennedy	895 Napa St., Ste.B5	Morro Bay	CA	93443	805-772-6043	805-772-5844
Reed & Graham, Inc.	Mark Bernardi	690 Sunol Street	San Jose	CA	95126	888-638-8604	408-977-0375
Reed & Graham, Inc.	Danny Reynaga	6560 Ambrosia Ln.	Carlsbad	CA	92009	760-431-5505	760-431-5501
Reed & Graham, Inc.	Jim Senn	690 Sunol Street	San Jose	CA	95126	888-638-8604	408-977-0375
Reed & Graham, Inc.	Carl Springer	26 Light Sky Court	Sacramento	CA	95828	888-381-0800	916-388-1486

List of Distributors

Distributor	Contact	Address				Phone Number	Fax
Reed & Graham, Inc.	Lynn Friesner	20645 Gas Point Road	Cottonwood	CA	96022	530-347-3413	530-347-5873
Reed & Graham, Inc.	Scott Brown	20645 Gas Point Road	Cottonwood	CA	96022	530-347-9126	530-347-5873
Reed & Graham, Inc.	LLoyd Gilbreath	3709 Duck Creek Road	Stockton	CA	95205	209-467-2420	209-465-7432
Reed & Graham, Inc.	Russ Daveggio	3709 Duck Creek Road	Stockton	CA	95205	916-381-9900	209-465-7432
RFQ, Inc.	Michael Lerner	830 La Playa Way	San Rafael	CA	94903-2920	415-479-5600	415-479-5666
Sacramento Bag Mfg. Co.	Chris Marr	530 Q Street	Sacramento	CA	95812	800-287-2247	916-441-7860
SI Geosolutions	John McCarty					775-345-1114	775-848-8544
South Coast Supply	Bonnie Jark	3626 Cerritos	Los Alamites	CA	90720	562-596-6662	
S&S Seeds, Inc.		P.O. Box 1275	Carpinteria	CA	93014-1275	805-684-0436	805-684-2798
Stover Seed Co.						213-626-9668	
Telfers		1150 Willow Pass Road	Pittsburg	CA	94565	925-432-1596	
United Green Mark	Gilbert Contreras	6609 Edith Blvd. NE	Albuquerque	NM	87113	505-344-3474	505-344-9102
United Green Mark	Ron Haines	1301 N. Tustin Avenue	Anaheim	CA	92807	714-996-9937	714-996-9679
United Green Mark	Bill Gerwe	200-C Traffic Way	Arroyd Grande	CA	93420	805-481-7855	805-481-9455
United Green Mark	Jerry Schuler	7245 W. 116th Place	Broomfield	CO	80020	303-922-4000	303-404-3854

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Distributor	Contact	Address				Phone Number	Fax
United Green Mark	Rich Gageant	819 Anita Street	Chula Vista	CA	91911	619-423-9060	619-423-9056
United Green Mark	Jim Fitzgerald	2197 W. College Avenue	Englewood	CO	80110	303-922-4000	303-922-4568
United Green Mark	Glen Mc Intosh	4950 Northpark Drive	Colorado Springs	CO	80918	719-598-8888	719-598-8538
United Green Mark		4895 Olive Street	Commerce City	CO	80022	303-289-1950	303-289-7665
United Green Mark	Gary Peters	6450-B Trinity Court	Dublin	CA	94568	925-829-6040	925-829-0110
United Green Mark	Tony Dunayevich	1073 N. Marshall	El Cajon	CA	92020	619-562-8777	619-562-9220
United Green Mark	John Thomason	900 W. Washington Ave.	Escondido	CA	92025	760-480-0060	760-747-0792
United Green Mark	Kelly Foraker	143 E. Sierra Avenue	Fresno	CA	93710	559-431-9220	559-431-6949
United Green Mark	Isaias Ramos	981 Empire Mesa Way	Henderson	NV	89015	702-558-5022	702-558-3870
United Green Mark	Chuck Smith	15579 E. Hinsdale Circle	Englewood	CO	80112	303-617-4208	303-690-3730
United Green Mark	Mike Romero	1772 Reynolds Avenue	Irvine	CA	92614	949-250-9735	949-250-8195
United Green Mark	Miguel Zendejas	23432 So. Pointe Drive	Laguna Hills	CA	92653	949-837-4460	949-837-0213
United Green Mark	Don Phinney	3670 West Dewey Drive	Las Vegas	NV	89118	702-736-8188	702-736-1190
United Green Mark	Bill Wiggins	5102 N. Garfield	Loveland	CO	80538	970-667-3337	970-667-3525
United Green Mark	Mike Harris	701 Kearney Avenue, Bldg #8	Modesto	CA	95350	209-521-6011	209-521-6996

List of Distributors

Distributor	Contact	Address				Phone Number	Fax
United Green Mark	Greg Worthey	26713 Madison Avenue	Murrieta	CA	92562	909-698-1890	909-698-8854
United Green Mark	Marvin McCormick	7514 Redwood Blvd	Novato	CA	94948	415-897-1171	415-892-4914
United Green Mark	Wai Powell	130-A So. Buchanan Circle	Pacheco	CA	94553	925-680-7620	925-825-6133
United Green Mark	Scotty Powell	74-991 Velie Way	Palm Desert	CA	92260	760-776-4250	760-776-4255
United Green Mark	Chris Nagelschmidt	1850 Ramada Drive, Unit # 4	Paso Robles	CA	93446	805-227-0415	805-227-0418
United Green Mark	Ryan Morton	2540-F Grennan Court	Rancho Cordova	CA	95742	916-635-1200	916-635-7828
United Green Mark	George Ramsey	2656 Market Street	Riverside	CA	92501	909-684-1080	909-781-6802
United Green Mark	Kenny Kakutani	1675 Nichols Road	Rocklin	CA	95765	916-408-0024	916-408-0781
United Green Mark	Ryan Butler	6500 Elvas Avenue	Sacramento	CA	95819	916-452-8041	916-452-3283
United Green Mark	Ira Yesselman	9530 Candida Street	San Diego	CA	92126	858-536-3470	858-693-0214
United Green Mark	Dave Usher	1145 No. 13th Street	San Jose	CA	95112	408-295-3376	408-295-3470
United Green Mark	Joe Morton	1158 19th Avenue	San Mateo	CA	94403	650-349-0316	650-349-0384
United Green Mark	Raul Sanchez	25655 Springbrook Avenue - 2C	Saugus	CA	91350	661-288-0046	661-288-0079
United Green Mark	Dewayne Owens	2662 Santa Maria Way	Santa Maria	CA	93455	805-922-1761	805-349-8863
United Green Mark	Kory Hopkins	180 Sabastopol Road	Santa Rosa	CA	95407	707-526-1171	707-526-1938

List of Distributors

Distributor	Contact	Address				Phone Number	Fax
United Green Mark	Keith Johnson	4045 Sunset Lane	Shingle Springs	CA	95682	530-677-0357	530-676-9640
United Green Mark	Jason Westcott	1245 West Geneva Drive	Tempe	AZ	85282	480-966-2424	480-966-0752
United Green Mark	Sid Schreiber	31240 La Baya Drive	Westlake Village	CA	91362	818-991-7216	818-991-5014
United Green Mark	Jim Baier	7514 Redwood Blvd	Novato	CA	94948	415-209-2142	415-897-3084
West Tek Supply, Inc.	Tom Franceschi	1335 North 10th Street	San Jose	CA	95112-4302	800-575-8881	408-920-0289

APPENDIX B
Site Questionnaire and BMP Selection Flowchart

The following site questionnaire and BMP selection flowchart are designed to assist in the approval of the temporary soil stabilization BMPs. Fill out the site questionnaire to document the site characteristics. Use the flowchart to quickly see if the temporary soil stabilization BMP selected by the contractor will be applicable to the construction site. Refer to the Tables provided in Sections 2.2.1 through 2.2.6 (Applicability to BMP (SS-#) Site Characteristics) regarding details of what temporary soil stabilization BMPs are applicable to the site characteristics.

APPENDIX B
Site Questionnaire and BMP Selection Flowchart

Site Questionnaire

1) What is the flow condition?

Sheet	
Channelized	
Run-on	
Run-off	

2) What is the slope inclination range?

Less than or equal to 1:4 (V:H)	
Between 1:4- and 1:2 (V:H)	
Equal to or greater than 1:2 (V:H)	

3) What is the soil classification?

GW		ML	
GP		CL	
GM		OL	
GC		MH	
SW		CH	
SP		OH	
SM		Pt	
SC			

4) What is the surface area of the common flow condition, slope inclination, and soil classification?

Less than or equal to 0.4 ha	
Between 0.4 ha and 10 ha	
Equal to or greater than 10 ha	

5) What is the duration of need?

Less than 3 months	
Between 3 and 12 months	
Greater than 12 months	

Input as many details as possible regarding the atmospheric conditions expected during active construction.

6) Duration of construction is: ________________ to _____________

7) Will the site be prone to high winds? Y N

8) Prominent wind direction is from the: N NE E SE S SW W NW

9) Temperature range will be: ________ to ________

10) Humidity range will be: ________ to ________

11) Will the site be prone to fog or high moisture? Y N

12) Is rain probable during the construction period? Y N

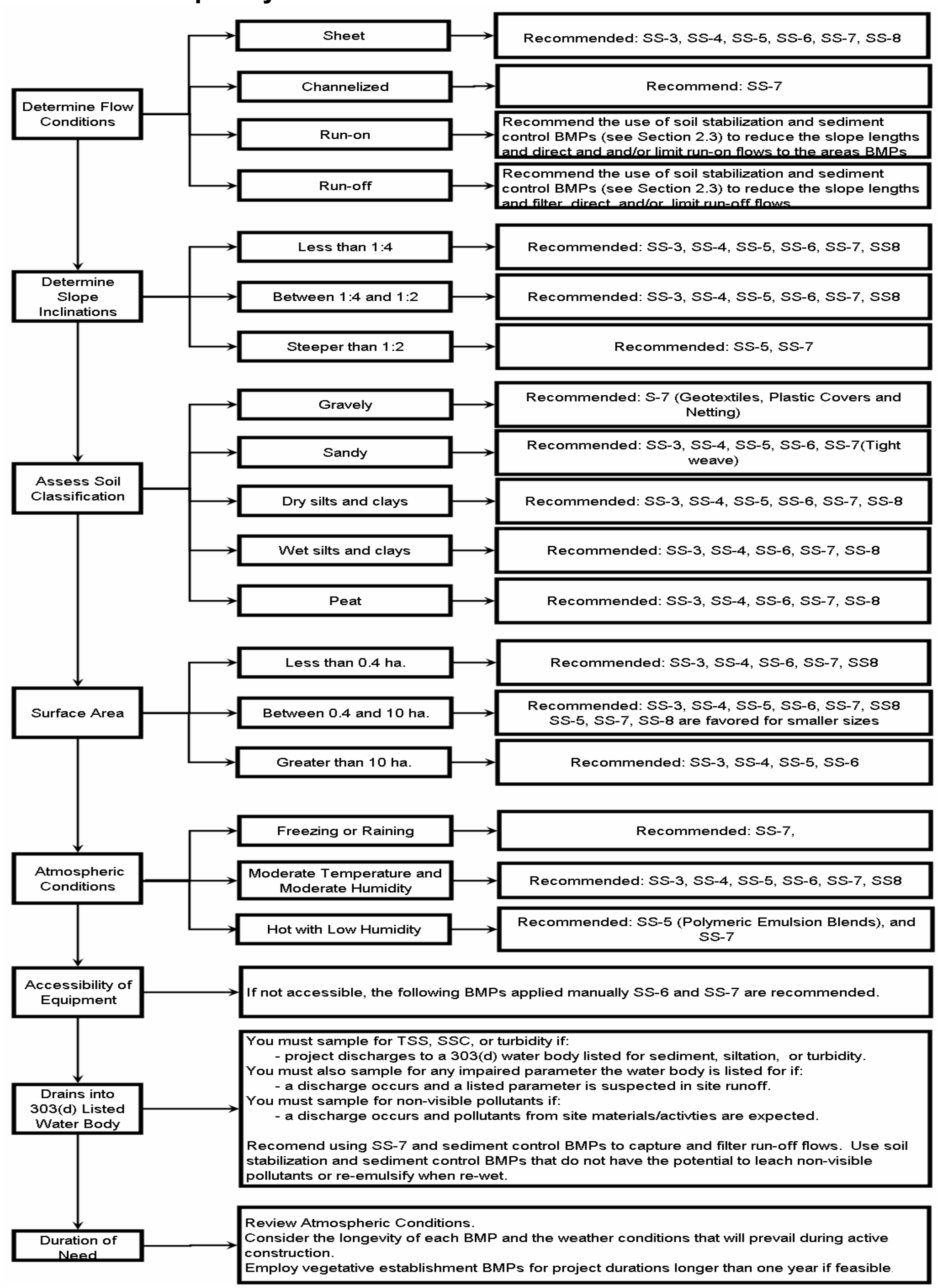
13) Is there a potential for flash flooding? Y N

14) Is equipment able to access the site? Y N

15) Is there a 303(d) listed water body in the project's drainage area? Y N

16) Does the site drain into a 303(d) Listed Water Body? Y N

Temporary Soil Stabilization BMP Selection Flowchart



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APPENDIX C
Abbreviations, Acronyms, and Definitions of Terms

GLOSSARY OF TERMS

The information provided in this section includes acronyms and terms that are encountered when discussing soil stabilization.

ACRONYMS

BFM	Bonded Fiber Matrix
BMP	Best Management Practice
CFR	Code of Federal Regulations
COC	Chain-of-Custody
CWA	Clean Water Act
ECB	Erosion Control Blanket
EPA	United States Environmental Protection Agency
MS4	Municipal Separate Storm Sewer System
NOC	Notification of Construction
NOCC	Notice of Completion of Construction
NOI	Notice of Intent
NOT	Notice of Termination
NPDES	National Pollutant Discharge Elimination System
NPS	Non-Point Sources
PA/ED	Project Approval/Environmental Document
PID	Project Initiation Document
PR	Project Report
PS&E	Plans, Specifications, and Engineers Estimate
PSR	Project Study Report
PSSR	Project Scope Summary Report
RECP	Rolled Erosion Control Product
SSP	Standard Special Provision
SWPPP	Storm Water Pollution Prevention Plan
TMDL	Total Maximum Daily Load
WPCP	Water Pollution Control Plan

DEFINITIONS

Accretion. The outward growth of a bank or shore by sedimentation. An increase or extension of the boundaries of land by action of natural forces.

Active Construction Area. Construction areas where soil-disturbing activities have already occurred and continue to occur or will occur during the ensuing 21 days. This may include areas where soils have been disturbed as well as areas where soil disturbance has not yet occurred.

Aggradation. General and progressive raising of a stream bed by deposition of sediment. Modification of the earth's surface in the direction of uniformity of grade, or slope, by deposition as in a river bed.

Aggressive. Refers to the corrosive properties of soil and water.

AlluviaL Referring to deposits of silts, sands, gravels and similar detrital materials that have been transported by running water.
Alluvium. Stream-borne. materials deposited in and along a channel.

Annuals. Plant species that complete their life cycle in one growing season.

Apron. A lining of the bed of the channel upstream or downstream from a lined or restricted waterway. A floor or lining of concrete, rock, etc., to protect a surface from erosion such as the pavement below chutes, spillways, at the toes of dams, or along the toe of bank protection.

Aqueduct, (1) A major conduit. (2) The entire transmission main for a municipal water supply that may consist of a succession of canals, pipes, tunnels, etc. (3) Any conduit for water, especially one for a large quantity of flowing water. (4) A structure for conveying a canal over a river or hollow.

Aquifer. Water-bearing geologic formations that permit the movement of ground water.

Arid Area. Area receiving less than 10 inches of rainfall per year.

Armor. Artificial surfacing of bed, banks, shore or embankment to resist erosion or scour.

Arroyo. Waterway of an ephemeral stream deeply carved in rock or ancient alluvium.

Artesian Waters. Percolating waters confined below impermeable formations with sufficient pressure to spring or well up to the surface.

Articulated. Made flexible by hinging particularly of small rigid slabs adapted to revetment.

Avulsion. (1) A forcible separation; also, a part torn off. (2) The sudden removal of land from the estate of one person to that of another, as by a sudden change in a river, the property thus separated continuing in the original owner. (3) A sudden shift in location of channel.

Backfill. Earth used to fill a trench or excavation.

Backing Layer. A layer of graded rock between rock riprap and underlying engineering fabric or filter layer to prevent extrusion of the soil or filter layer material through the riprap.

Backs ho re. The zone of the shore or beach lying between the foreshore and the coastline and acted upon by waves only during severe storms, especially when combined with exceptionally high water.

Backwater. An unnaturally high stage in stream caused by obstruction or confinement of flow, as by a dam, a bridge, or a levee. Its measure is the excess of unnatural over natural stage, not the difference in stage upstream and downstream from its cause.

Baffle. A pier, vane, sill, fence, wall or mound built on the bed of a stream to parry, deflect, check or disturb the flow or to float on the surface to deflect or dampen cross currents or waves.

Bank. The lateral boundary of a stream confining water flow. The bank on the left side of a channel looking downstream is called the left bank, etc.

Bank Protection. Revetment, or other armor protecting a bank of a stream from erosion, includes devices used to deflect the forces of erosion away from the bank.

Bar. An elongated deposit of alluvium within a channel or across its mouth.

Barrier. A low dam or rack built to control flow of debris.

Base Flood. The flood or tide having a 1 percent chance of being exceeded in any given year (100-year flood). The “base flood” is commonly used as the “standard flood” in Federal flood insurance studies. (see Regulatory Flood).

Base Floodplain. The area subject to flooding by the base flood.

Base Flow. The flow contribution to a creek by groundwater. During dry periods, base flow constitutes most stream flow.

Basin. (1) The surface of the area tributary to a stream or lake. (2) Space above or below ground capable of retaining or detaining water or debris.

Bay. An indentation of bank or shore, including erosional cuts and slipouts, not necessarily large.

Beach. The zone of sedimentary material that extends landward from the low water line to the place where there is marked change in material or form, or to the line of permanent vegetation (usually the effective limit of storm waves). The seaward limit of a beach, unless otherwise specified, is the mean low water line. A beach includes foreshore and backshore.

Bed. The earth below any body of water, limited laterally by bank or shore.

Bed Load. Sediment that moves by rolling, sliding, or skipping along the bed and is essentially in contact with the stream bed.

Bedding. The foundation under a drainage structure.

Beneficial Uses. As referred to in the State Water Quality Standards, beneficial uses are activities that range from recreational to agricultural uses, depending on the source of the water.

Berm. (1) A bench or terrace between two slopes. (2) A nearly horizontal part of the beach or backshore formed at the high water line by waves depositing material. Some beaches have no berms, other have one or several.

Best Management Practice (EMP). (1) A measure that is implemented to protect water quality and reduce the potential for pollution associated with storm water runoff. (2) Any program, technology, process, siting criteria, operating method, measure, or device that controls, prevents, removes, or reduces pollution.

Biofiltration. The use of vegetated strips and swales to trap sediment and other contaminants in overland sheet flow. Pollutants are removed by filtration through the grass, sedimentation, adsorption to soil particles, and infiltration through the soil.

Block Pre-cast prismatic unit for riprap structure.

Bluff A high, steep bank composed of erodible materials.

Boil. Turbulent break in a water surface by upwelling.

Boom. Floating log or similar element designed to dampen surface waves or control the movement of drift.

Bore. A transient solitary wave in a narrow or converging channel advancing with a steep turbulent front; product of flash floods or in-coming tides.

Boulder. Largest rock transported by a stream or rolled in the surf; arbitrarily heavier than 12 kg and larger than 200 mm.

Braided Stream. A stream in which flow is divided at normal stage by small islands. This type of stream has the aspect of a single large channel with which there are subordinate channels.

Breaker. A wave meeting a shore, reef, sandbar, or rock and collapsing.

Breakwater. A fixed or floating structure that protects a shore area, harbor, anchorage, or basin by intercepting waves.

Bulkhead. A steep or vertical structure placed on a bank, bluff, or embankment to retain or prevent sliding of the land and protect the inland area against damage.

Bulking. The increase in volume of flow due to air entrainment, debris, bedload, or sediment in suspension.

Buoyancy. Uplift force on a submerged body equal to the mass of water displaced times the acceleration of gravity.

Camber. •An upward adjustment of the profile of a drainage facility under a heavy loading (usually a high embankment) and poor soil conditions, so that as the drainage facility settles it approaches the design profile.

Canal. An artificial open channel.

Canyon. A large deep valley; also the sub-marine counterpart.

Cap. Top layer of stone protective works.

Capacity. The effective carrying ability of a drainage structure. Generally measured in cubic meters per second.

Cap illarity. The attraction between water and soil particles which cause water to move in any direction through the soil mass regardless of gravitational forces.

Capillary Water. Water which clings to soil particles by capillary action. It is normally associated with fine sand, silt, or clay, but not normally with coarse sand and gravel.

Catch Basin. A drainage structure which collects water. May be either a structure where water enters from the side or through a grating.

Causeway. A raised embankment or trestle over swamp or overflow areas.

Cavitation. Erosion by suction, especially in the partial vacuum of a diverging jet.

Celerity. Velocity of a moving wave, as distinguished from velocity of particles oscillating in the wave.

Chain of Custody (COC) Form. A form used to track sample handling as samples progress from sample collection to the analytical laboratory. The COC is then used to track the resulting analytical data from the laboratory to the client. COC forms can be provided by an analytical laboratory upon request

Channel. The space above the bed and between banks occupied by a stream.

Channelization. The process of making a channel or channels. A channel is the bed of a stream or river, or the hollow or course in which a stream flows.

Check. A sill or weir in a channel to control stage or velocity.

Check Dam. A small dam generally placed in steep ditches for the purpose of reducing the velocity in the ditch.

Cienega. A swamp formed by water rising to the surface at a fault.

Clean Water Act (CWA). The Federal Water Pollution Control Act enacted in 1972 by Public Law 92-500 and amended by the Water Quality Act of 1987. The Clean Water Act prohibits the discharge of pollutants to Waters of the United States unless said discharge is in accordance with an NPDES permit. The 1987 amendments include guidelines for regulating municipal, industrial, and construction storm water discharges under the NPDES program.

Cleanout. An access opening to a roadway drainage system. Usually consists of a manhole shaft, a special chamber or opening into a shallow culvert or drain.

Cliff A high, steep face of rock; a precipice.

Cloudburst. Rain storm of great intensity usually over a small area for a short duration.

Coast. (1) The strip of land, of indefinite width (up to several kilometers), that extends from the shoreline inland to the first major change in terrain features. (2) As a combining form, up-coast is northerly and down-coast is southerly.

Cobble. Rock smaller than a boulder and larger than gravel; arbitrarily 0.5 to 12 kg, or 75 to 200 mm in diameter.

Coefficient of Runoff Percentage of gross rainfall which appears as runoff.

Composite Hydrograph. A plot of mean daily discharges for a number of years of record on a single year time base for the purpose of showing the occurrence of high and low flows.

Concentrated Flow. Flowing water that has been accumulated into a single fairly narrow stream.

Concentration. In addition to its general sense, means the unnatural collection or convergence of waters so as to discharge in a narrower width, and at greater depth or velocity.

Conduit~ Any pipe, arch, box or drain tile through which water is conveyed.

Cone. Physiographic form of sediment deposit washed from a gorge channel onto an open plain; a debris cone, also called an alluvial fan.

Confluence. A junction of streams.

Constriction. An obstruction narrowing a waterway.

Construction Activity. (1) Includes clearing, grading, or excavation and contractor activities that result in soil disturbance. (2) Any operation or process, employed to build the project, with the potential to discharge pollutants.

Construction Site. The area involved in a construction project as a whole.

Contraction. The reduction in cross sectional area of flow.

Contractor. Party responsible for carrying out the contract per plans and specifications.

ControL (1) A section or reach of an open conduit or stream channel which maintains a stable relationship between stage and discharge. (2) For flood, erosion, debris, etc., remedial means or procedure restricting damage to a tolerable level.

Conveyance. (1) A measure of the water carrying capacity of a stream or channel. (2) Any natural or man-made channel or pipe in which concentrated water flows.

Core. Central zone of dike, levee, rock groin, jetty, etc.

Corrasion. Erosion or scour by abrasion in flowing water.

Corrosion. Erosion by chemical action.

Cradle. A concrete base generally constructed to fit the shape of a structure that is to be forced through earthen material by a jacking operation. The cradle is constructed to line and grade. Then the pipe rides on the cradle as it is worked through the given material by jacking and tunneling methods. Also serves as bedding for pipes in trenches in special conditions.

Creek. A small stream, usually active.

Crest (1) Peak of a wave or a flood. (2) Top of a levee, dam, weir, spillway or other water barrier or control.

Crib. An open-frame structure loaded with earth or stone ballast to act as a baffle in bank protection.

Critical Depth. (Depth at which specific energy is a minimum) - The depth of water in a conduit at which under certain other conditions the maximum flow will occur. These other conditions are the conduit is on the critical slope with the water flowing at its critical velocity and there is an adequate supply of water. The depth of water flowing in an open channel or a conduit partially filled, for which the velocity head equals one-half the hydraulic mean depth.

Critical Flow. That flow in open channels at which the energy content of the fluid is at a minimum. Also, that flow which has a Froude number of one.

Critical Slope. That slope at which the maximum flow will occur at the minimum velocity. The slope or grade that is exactly equal to the loss of head per meter resulting from flow at a depth that will give uniform flow at critical depth; the slope of a conduit which will produce critical flow.

Critical Velocity. Mean velocity of flow when flow is at critical depth.

Culvert, A closed conduit, other than a bridge, which allows water to pass under a highway. A culvert has a span of less than 6.1 m, or if multispan, the individual spans are 3.0 m or less.

Current. Flow of water, both as a phenomenon and as a vector. Usually qualified by adjectives like downward, littoral, tidal, etc. to show relation to a pattern of movement.

Current Meter. An instrument for measuring the velocity of a current. It is usually operated by a wheel equipped with vanes or cups which is rotated by the action of the impinging current. An indicating or recording device is provided to indicate the speed of rotation, which is correlated With the velocity of the current.

Cutoff WalL A wall at the end of a drainage structure, the top of which is an integral part of the drainage structure. This wall is usually buried, and its function is to prevent undermining of the drainage structure if the natural material at the outlet of the structure is scoured by the water discharging from the end of the structure. Cutoff walls are sometimes used at the upstream end of a structure when there is a possibility of erosion at this point.

Debris. Any material including floating woody materials and other trash, suspended sediment, or bed load moved by a flowing stream.

Debris Barrier. A deflector placed at the en-trance of a culvert upstream, which tends to deflect heavy floating debris or boulders away from the culvert entrance during high-velocity flow.

Debris Basin. Any area upstream from a drainage structure used for the purpose of retaining debris to prevent clogging of drainage structures downstream.

Debris Rack. A straight barrier that, when placed across the stream channel, tends to separate light and medium floating debris from stream flow and prevent the debris from reaching the culvert entrance.

Degradation. General and progressive lowering of the longitudinal profile of a channel by erosion.

Delta. System of channels through an alluvial plain at the mouth of a stream.

Denuded. Land stripped of vegetation.

Deposit. An earth mass of particles settled or stranded from moving water or wind.

Depth. Vertical distance, (1) from surface to bed of a body of water. (2) From crest or crown to invert of a conduit.

Design Discharge. The quantity of flow that is expected at a certain point as a result of a design storm. Usually expressed as a rate of flow in cubic meters per second.

Design Flood. The peak discharge (when appropriate, the volume, stage, or wave crest elevation) of the flood associated with the probability of exceedance selected for the design of an encroachment in a FEMA flood plain.

Design Frequency. The recurrence interval for hydrologic events used for design purposes. As an example, a design frequency of 50 years means a storm of a magnitude that would be expected to recur on the average of every 50 years. (See Probability of Exceedance.)

Design High Water. The flood stage or tide crest elevation adopted for design of drainage and bank protection structures. (See Design Flood and High Water).

Design Storm. That particular storm which contributes runoff which the drainage facilities were designed to handle. This storm is selected for design on the basis of its probability of exceedance or average recurrence interval (See Probability of Exceedance.)

Detention. The process of temporarily collecting and holding back storm water for later release to receiving waters.

Detention Storage. Surface water moving over the land is in detention storage. Surface water allowed to temporarily accumulate in ponds, basins, reservoirs or other types of holding facility and which is ultimately re-turned to a watercourse or other drainage system as runoff is in detention storage. (See Retention Storage)

Detritus. Loose material such as; rock, sand, silt, and organic particles.

Dike. (1) Usually an earthen bank alongside and parallel with a river or open channel to restrict overflow (See Levee). (2) An asphalt concrete berm along the edge of a shoulder.

Dike, Finger. Relatively short embankments constructed normal to a larger embankment, such as an approach fill to a bridge. Their purpose is to impede flow and direct it away from the major embankment.

Dike, Spur. Relatively short embankments constructed at the upstream side of a bridge end for the purpose of aligning flow with the waterway opening and to move scour away from the bridge abutment.

Dike, Toe. Embankments constructed to prevent lateral flow from scouring the corner of the downstream side of an abutment embankment. Sometimes referred to as training dikes.

Dike, Training. Embankments constructed to provide a transition from the natural stream channel or floodplain, both to and from a constricting bridge crossing.

Discharge. A volume of water flowing out of a drainage structure or facility. Measured in cubic meters per second.

Dissipate. Expend or scatter harmlessly, as of energy of moving water.

Disturbed Soil Areas (DSAs). Areas of exposed, erodible soil, including stockpiles, that are within the construction limits and that result from construction activities.

Ditch. Small artificial channel, usually unlined.

Diversion. (1) The change in character, location, direction, or quantity of flow of a natural drainage course (a deflection of flood water is not a diversion). (2) Draft of water from one channel to another. (3) Interception of runoff by works which discharge it through unnatural channels.

D-Load (Cracking D-Load). A term used in expressing the strength of concrete pipe. The cracking D-load represents the test load required to produce a 0.3 mm crack for a length of 300 mm.

Downdrain. A prefabricated drainage facility assembled and installed in the field for the purpose of transporting water down steep slopes.

Downdrift. The direction of predominant movement of littoral materials.

Drain. Conduit intercepting and discharging surplus ground or surface water.

Drainage. (1) The process of removing surplus ground or surface water by artificial means. (2) The system by which the waters of an area are removed. (3) The area from which waters are drained; a drainage basin.

Drainage Area (Drainage Basin) (Basin). That portion of the earth's surface upon which falling precipitation flows to a given location.

Drainage Course. Any path along which water flows when acted upon by gravitational forces.

Drainage Divide. The rim of a drainage basin. A series of high points from which water flows in two directions, to the basin and away from the basin.

Drainage Easement (See Easement).

Drainage System. Usually a system of underground conduits and collector structures which flow to a single point of discharge.

Drawdown. The difference in elevation between the water surface elevation at a constriction in a stream or conduit and the elevation that would exist if the constriction were absent. Drawdown also occurs at changes from mild to steep channel slopes and weirs or vertical spillways.

Drift. (1) Floating or non-mineral burden of a stream. (2) Deviation from a normal course in a cross current, as in littoral drift.

Drop. Controlled fall in a stream to dissipate energy.

Dry Weather Flows. A small amount of water which flows almost continually due to lawn watering, irrigation or springs.

Dune. A sand wave of approximately triangular cross section (in a vertical plane in the direction of flow) formed by moving water or wind, with gentle upstream slope and steep downstream slope and deposition on the downstream slope.

Easement. Right to use the land of others.

Ebb. Falling stage or outward flow, especially of tides.

Eddy Loss. The energy lost (converted into heat) by swirls, eddies, and impact, as distinguished from friction loss.

Eddy. Rotational flow around a vertical axis.

Electrical Conductivity (EC*).* Electric Conductivity is a measure of the ability of water to carry an electric current. This ability depends on the presence of ions, their concentration, valence, mobility and temperature. EC measurements can give an estimate of the variations in the dissolved mineral content of storm water in relation to receiving waters.

Embankment. Earth structure above natural ground.

Embayment. Indentation of bank or shore, particularly by progressive erosion.

Encroachment. Extending beyond the original, or customary limits, such as by occupancy of the river and/or flood plain by earth fill embankment.

Endwall. A wall placed at the end of a culvert, it may serve three purposes; one, to hold the embankment away from the pipe and prevent sloughing into the pipe outlet channel; two, to provide a wall which will prevent erosion of the roadway fill; and three, to prevent flotation of the pipe.

Energy. Potential or kinetic, the latter being expressed in the same unit (meters) as the former.

Energy Dissipator. A structure for the purpose of slowing the flow of water and reducing the erosive forces present in any rapidly flowing body of water.

Energy Grade Line. The line which represents the total energy gradient along the channel. It is established by adding together the potential energy expressed as the water surface elevation referenced to a datum and the kinetic energy (usually expressed as velocity head) at points along the stream bed or channel floor.

Energy Head, The elevation of the hydraulic grade line at any section plus the velocity head of the mean velocity of the water in that section.

Entrance. The upstream approach transition to a constricted waterway.

Entrance Head. The head required to cause flow into a conduit or other structure; it includes both entrance loss and velocity head.

Entrance Loss. The head lost in eddies and friction at the inlet to a conduit or structure.

Environmental Protection Agency (EPA). Agency that issued the regulations to control pollutants in storm water runoff discharges (The Clean Water Act and NPDES permit requirements).

Ephemeral. Of brief duration, as the flow of a stream in an arid region.

Equalizer. A drainage structure similar to a culvert but different in that it is not intended to pass a design flow in a given direction. Instead it is often placed level so as to permit passage of water in either direction. It is used where there is no place for the water to go. Its purpose is to maintain the same water surface elevation on both sides of an embankment.

Erosion. The process which, by the actions of wind or water, soil particles are detached and transported.

Erosion and Accretion. Loss and gain of land, respectively, by the gradual action of a stream in shifting its channel by cutting one bank while it builds on the opposite bank. Property is lost by erosion and gained by accretion but not by avulsion when the shift from one channel to another is sudden. Property is gained by reliction when a lake recedes.

Erosion and Scour. The cutting or wearing away by the forces of water of the banks and bed of a channel in horizontal and vertical directions, respectively.

Erosion Control The use of practices and measures, both vegetative and inert, to reduce the loss of soil by wind or water with the goals of protecting slopes and preventing water pollution.

Estuary. That portion of a river channel occupied at times or in part by both sea and river flow in appreciable quantities. The water usually has brackish characteristics.

Evaporation. A process whereby water as a liquid is changed into water vapor, typically through heat supplied from the sun.

Excavation. The process of removing earth, stone, or other materials.

Existing Vegetation. Any vegetated area that has not already been cleared and grubbed.

Face. The outer layer of slope revetment.

Fair Weather Prediction. When there is no precipitation in the forecast between the current calendar day and the next working day.

Fan. A portion of a cone, but sometimes used to emphasize definition of radial channels. In addition, reference to spreading out of water or soils associated with waters leaving a confined channel.

Feasible. Economically achievable or cost-effective measures which reflect a reasonable degree of pollutant reduction achievable through the application of available non-point pollution control practices, technologies, processes, site criteria, operating methods, or other alternatives.

Fetch. The unobstructed distance over water in which waves are generated by wind of relatively constant direction and speed.

Field Measurements. Water quality testing performed in the field with portable field-testing kits or meters.

Field Tracking Form (FTF). A field tracking form serves as a guide to sampling crews to obtain sampling information and to prescribe and document sample collection information in the field. The FTF usually contains sample identifiers, sampling locations, requested analyses, QC sample identifiers, special instructions, and field notes.

Filter. A porous article or mass (as of fabric or even-graded mineral aggregate) through which water will freely pass but which will block the passage of soil particles.

Filter Fabric (RSP fabric). An engineering fabric (geotextile) placed between the backfill and supporting or underlying soil through which water will pass and soil particles are retained.

Filter Layer. A layer of even-graded rock between rock riprap and underlying soil to prevent extrusion of the soil through the riprap.

Flap Gate. A form of valve that is designed so that a minimum force is required to push it open but when a greater water pressure is present on the outside of the valve, it remains shut so as to prevent water from flowing in the wrong direction. Construction is simple with a metal cover hanging from an overhead rod or pinion at the end of a culvert or drain.

Flood Frequency. Also referred to as exceedance interval, recurrence interval or return period; the average time interval between actual occurrences of a hydrological event of a given or greater magnitude; the percent chance of occurrence is the reciprocal of flood frequency, e.g., a 2 percent chance of occurrence is the reciprocal statement of a 50-year flood.

Flood Plane. The position occupied by the water surface of a stream during a particular flood. Also, loosely, the elevation of the water surface at various points along the stream during a particular flood.

Flood Stage. The elevation at which overflow of the natural banks of a stream begins to cause damage in the reach in which the elevation is measured.

Flood Stage. The elevation at which overflow of the natural banks of a stream begins to run uncontrolled in the reach in which the elevation is measured.

Flood Waters. Former stream waters which have escaped from a watercourse (and its overflow channel) and flow or stand over adjoining lands. They remain as such until they disappear from the surface by infiltration, evaporation, or return to a natural watercourse. They do not become surface waters by mingling with such waters, nor stream waters by eroding a temporary channel.

Floodplain Encroachment An action within the limits of the base flood plain.

Floodplain. Normally dry land areas subject to periodic temporary inundation by stream flow or tidal overflow. Land formed by deposition of sediment by water; alluvial land.

Flood-proof. To design and construct individual buildings, facilities, and their sites to protect against structural failure, to keep water out or reduce the effects of water entry.

Flow. A term used to define the movement of water, silt, sand, etc.; discharge; total quantity carried by a stream.

Flow Line. A term used to describe the line connecting the low points in a watercourse.

Flow Regime. The system or order characteristic of stream-flow with respect to velocity, depth, and specific energy.

Flow, steady. Flow at constant discharge.

Flow, unsteady. Flow on rising or falling stages.

Flow, varied Flow in a channel with variable section.

Foreshore. The part of the shore lying between the ordinary high water mark or upper limit of wave wash traversed by the run-up and return of waves and the water’s edge at the low water.

Free Outlet A condition under which water discharges with no interference such as a pipe discharging into open air.

Free Water. Water which can move through the soil by force of gravity.

Freeboard (1) The vertical distance between the level of the water surface usually corresponding to the design flow and a point of interest such as a bridge beam, levee top or specific location on the roadway grade. (2) The distance between the normal operating level and the top of the sides of an open conduit; the crest of a dam, etc., designed to allow for wave action, floating debris, or any other condition or emergency, without overtopping the structure.

French Drain. A trench loosely backfilled with stones, the largest stones being placed in the bottom with the size of stones decreasing towards the top. The interstices between the stones serve as a passageway for water.

Friction. Energy-dissipating conflict among turbulent water particles disturbed by irregularities of channel surface.

Froude Number. A dimensionless expression of the ratio of inertia forces to gravity forces, used as an index to characterize the type of flow in a hydraulic structure in which gravity is the force producing motion and inertia is the resisting force. It is equal to a characteristic flow velocity (mean; surface, or maximum) of the system divided by the square root of the product of a characteristic dimension (as diameter of depth) and the gravity constant (acceleration due to gravity) all expressed in consistent units
Fr = VI(.gy)$^{1\sim}$.

Gabion. A wire basket or cage filled with stone and placed as, or as part of, a bank-protection structure.

Gaging Station. A location on a stream where measurements of stage or discharge are customarily made. The location includes a reach of channel through which the flow is uniform, a control downstream from this reach and usually a small building to house the recording instruments.

General Permit. A general permit for storm water discharges associated with industrial or construction activity issued by EPA or a delegated state under the NPDES storm water regulations.

Gorge. A narrow deep valley with steep or vertical banks.

Grade. Elevation of bed or invert of a channel.

Grade to Drain. A construction note often inserted on a plan for the purpose of directing the Contractor to slope a certain area in a specific direction, so that the surface waters will flow to a designated location.

Gradient (Slope). The rate of ascent or descent expressed as a percent or as a decimal as determined by the ratio of the change in elevation to the length.

Gradually Varied Flow. In this type of flow, changes in depth and velocity take place slowly over large distances, resistance to flow dominates and acceleration forces are neglected.

Gravel. Rock larger than sand and smaller than cobble, arbitrarily ranging in diameter from **5** to 50 mm.

Groin. A fingerlike barrier structure usually built perpendicular to the shoreline or oblique to primary motion of water, to trap littoral drift, retard erosion of the shore, or to control movement of bed material.

Ground Water. That water which is present under the earth's surface. Ground water is that situated below the surface of the land, irrespective of its source and transient status. Subterranean streams are flows of ground waters parallel to and adjoining stream waters, and usually determined to be integral parts of the visible streams~

Grouted. Bonded together with an inlay or overlay of cement mortar.

Gulch. A relatively young, well-defined and sharply cut erosional channel.

Gully. Diminutive of gulch.

Head. Represents an available force equivalent to a certain depth of water. This is the motivating force in effecting the movement of water. The height of water above any point or plane of reference. Used also in various compound expressions, such as energy head, entrance head, friction head, static head, pressure head, lost head, etc.

Headcutting. Progressive scouring and degrading of a streambed at a relatively rapid rate in the upstream direction, usually characterized by one or a series of vertical falls.

High Water. Maximum flood stage of stream or lake; periodic crest stage of tide. Historic HW is stage recorded or otherwise known.

Holding Time. Holding time is specified by the analytical method and is the elapsed time between the time the sample is collected and the time the analysis must be initiated.

Hydraulic. Pertaining to water in motion and the mechanics of the motion.

Hydraulic Gradient. A line that represents the relative force available due to the potential energy available. This is a combination of energy due to the height of the water and the internal pressure. In any open channel, this line corresponds to the water surface. In a closed conduit, if several openings were placed along the top of the pipe and open tubes inserted, a line connecting the water surface in each of these tubes would represent the hydraulic grade line.

Hydraulic Jump (or Jump). Transition of flow 'from the rapid to the tranquil state. A varied flow phenomenon producing a rise in elevation of water surface. A sudden transition from supercritical flow to the complementary subcritical flow, conserving momentum and dissipating energy.

Hydraulic Mean Depth. The area of the flow cross section divided by the water surface width.

Hydraulic Radius. The cross sectional area of a stream of water divided by the length of that

part of its periphery in contact with its containing conduit; the ratio of area to wetted perimeter.

Hydric. Characterized by, relating to or requiring an abundance of moisture.

Hydro graph. A graph showing stage, flow, velocity, or other property of water with respect to time.

Hydro graphic. Pertaining to the measurement or study of bodies of water and associated terrain.

Hydrography. Water Surveys. The art of measuring, recording, and analyzing the flow of water; and of measuring and mapping watercourses, shore lines, and navigable waters.

Hydrologic. Pertaining to the cyclic phenomena of waters of the earth; successively as precipitation, runoff, storage and evaporation, and quantitatively as to distribution and concentration.

Hydrology. The science dealing with the occurrence and movement of water upon and beneath the land areas of the earth. Overlaps and includes portions of other sciences such as meteorology and geology. The particular branch of Hydrology that a design engineer is generally interested in is surface runoff that is the result of excessive precipitation.

Hydrophyte. A perennial vascular aquatic plant having its over-wintering buds under water; a plant growing in water or in soil too waterlogged for most plants to survive.

Hydrostatic. Pertaining to pressure by and within water due to gravitation acting through depth.

Hyetograph. Graphical representation of rainfall intensity against time.

Impervious. A surface that cannot be easily penetrated; for instance, rain does not readily penetrate asphalt or concrete surfaces.

Impinge. To strike and attack directly, as in curvilinear flow where the current does not follow the curve but continues on tangent into the bank on the outside of bend in the channel.

Incised Channel Those channels which have been cut relatively deep into underlying formations by natural processes. Characteristics include relatively straight alignment and high, steep banks such that overflow rarely occurs, if ever.

Infiltration. The passage of water through the soil surface into the ground.

Inlet An entrance into a ditch, storm drain, or other water conveyance system.

Inlet Time. The time required for storm runoff to flow from the most remote point, in flow time, of a drainage area to the point where it enters a drain or culvert.

Inlet Transition. A specially shaped entrance to a box or pipe culvert. It is shaped in such a manner that in passing from one flow condition to another, the minimum turbulence or interference with flow is permitted.

Inundate. To cover with a flood.

Invert. The bottom of a drainage facility along which the lowest flows would pass.

Invert Paving. Generally applies to metal pipes where it is desirable to improve flow characteristics or prevent corrosion at low flows. The bottom portion of the pipe is paved with an asphaltic material, concrete, or air-blown mortar.

Inverted Siphon. A pipe for conducting water beneath a depressed place. A true inverted siphon is a culvert which has the middle portion at a lower elevation than either the inlet or the outlet and in which a vacuum is created at some point in the pipe. A sag culvert is similar, but the vacuum is not essential to its operation.

Isohyet/Isohyetal Line. A line drawn on a map or chart joining points that receive the same amount of precipitation.

Isohyetal Map. A map containing isohyetal lines and showing rainfall intensities.

Isovel. Line on a diagram of a channel or channel section connecting points of equal velocity.

Jack (or Jack Straw). Bank protection element consisting of wire or cable strung on three mutually perpendicular struts connected at their centers.

Jacking Operations. A means of constructing a pipeline under a highway without open excavation. A cuffing edge is placed on the first section of pipe and the pipe is forced ahead by hydraulic jacks. As the leading edge pushes ahead, the material inside the pipe is dug out and transported outside the pipe for disposal.

Jam. Wedged collection of drift in a constriction of a channel, such as a gorge or a bridge opening.

Jet. An effluent stream from a restricted channel, including a fast current through a slower stream.

Jetty. An elongated, artificial obstruction projecting into a stream or the sea from bank or shore to control shoaling and scour by deflection of strength of currents and waves.

Jump. Sudden transition from supercritical flow to the complementary subcritical flow, conserving momentum and dissipating energy; the hydraulic jump.

Kolk. Rotational flow about a horizontal axis, induced by a reef and breaking the surface in a boil.

Lag. Variously defined as time from beginning (or center of mass) .of rainfall to peak (or center of mass) of runoff.

Lake. A water filled basin with restricted or no outlet. Includes reservoirs, tidal ponds and playas.

Laminar Flow. That type of flow in which each particle moves in a direction parallel to every other particle and in which the head loss is approximately proportional to the velocity (as opposed to turbulent flow).

Lateral In a drainage system, a drainage conduit transporting water from inlet points to the main drain trunk line.

Levee. An embankment to prevent inundation, usually on or along the bank of a stream or lake to protect outer lowlands.(See Dike)

Lining. Protective cover of the perimeter of a channel.

Littoral Pertaining to or along the shore, particularly to describe currents, deposits, and drift.

Littoral Drift. The sedimentary material (sand) moved along the shoreline under the influence of waves and currents.

Littoral Transport. The movement of littoral drift along the shoreline by waves and currents. Includes movement parallel (long-shore transport) and perpendicular (on-offshore transport) to the shore.

Loading. The total amount of material entering a system from all sources.

Local Depression. A low area in the pavement or in the gutter established for the special purpose of collecting surface waters on a street and directing these waters into a drainage inlet.

Long-shore. Parallel to and near the shoreline.

Marginal. Within a borderland area; more general and extensive than riparian.

Marsh. An area of soft, wet, or periodically submerged land, generally treeless and usually characterized by grasses and other low vegetation.

Mature. Classification for reams which have established flat gradients not subject to further scour

Maximum Historical Flood The maximum flood that has been recorded or experienced at any particular highway location.

Mean Annual Flood The flood discharge with a recurrence interval of 2.33 years.

Mean Depth. For a stream at any stage, the wetted normal section divided by the surface width. Hydraulic mean depth.

Meander. In connection with streams, a winding channel usually in an erodible, alluvial valley. A reverse or S-shaped curve or series of curves formed by erosion of the concave bank, especially at the downstream end, characterized by curved flow and alternating shoals and bank erosions. Meandering is a stage in the migratory movement of the channel, as a whole, down the valley.

Meander Plug (Clay Plug). Deposits of cohesive materials in old channel bend-ways. These plugs are sufficiently resistant to erosion to serve as essentially semi-permanent geological controls to advancing channel migrations.

Meander Scroll Evidence of historical meander patterns in the form of lines visible on the inside of meander bends (particularly on aerial photographs) which resemble a spiral or convoluted form in ornamental design. These lines are concentric and regular forms in high sinuosity channels and are largely absent in poorly developed braided channels.

Mesh. Woven wire or other filaments used alone as revetment, or as retainer or container of masses of gravel or cobble.

Mud Flow. A well-mixed mass of water and alluvium which, because of its high viscosity, and low fluidity as compared with water, moves at a much slower rate, usually piling up and spreading out like a sheet of wet mortar or concrete.

Mulch. A natural or artificial layer of plant residue or other material that covers the land surface and conserves moisture, holds soil in place, aids in establishing vegetation, and reduces temperature fluctuations.

"n" Value. The roughness coefficient in the Manning formula for determination of the discharge coefficient in the Chezy formula,

V **= C(RS**)"~ , where C= (1/n)

National Pollutant Discharge Elimination System (NPDES). EPA's program to control the discharge of pollutants to waters of the United States. NPDES is a part of the federal CWA, which requires point and non-point source dischargers to obtain permits. These permits are referred to as NPDES permits.

Natural and Beneficial Floodplain Values. Includes but are not limited to fish, wildlife, plants, open space, natural beauty, scientific study, outdoor recreation, agriculture, aqua-culture, forestry, natural moderation of floods, water quality maintenance, and groundwater recharge.

Navigable Waters. Those stream waters lawfully declared or actually used as such. Navigable Waters of the United States are those determined by the Corps of Engineers or the U.S. Coast Guard to be so used in interstate or international commerce. Other streams have been held as navigable by courts under the common law that navigability in fact is navigability in law.

Negative Projecting Conduits. A structure installed in a trench with the top below the top of trench, then covered with backfill .and embankment. See Positive Projecting Conduit.

Non-active Construction Area. Any area not considered to be an active construction area. Active construction areas become non-active construction areas whenever construction activities are expected to be discontinued for a period of 21 days or longer.

Non-Point Sources (NPS). Diffuse sources from which contaminants originate to accumulate in surface water or groundwater. These sources can add to a cumulative problem with serious health or environmental consequences.

Non-uniform Flow. A flow in which the velocities vary from point to point along the stream or conduit, due to variations in cross section, slope, etc.

Normal Depth. The depth at which flow is steady and hydraulic characteristics are uniform.

Normal Water Surface (Natural Water Surface). The free surface associated with flow in natural streams.

Notice of Intent (NOI). A formal notice to the EPA or a state agency haying delegated NPDES authority that a construction project seeking coverage under a General Permit is about to begin. The NOI provides information on the owner, location, and type of project, and certifies that the permittee will comply with conditions of the construction General Permit. The NOI is **not** a permit application and no approval is required. Some local permits may require submittal of a Notice of New Construction (NONC) in lieu of filing a NOI with the state or EPA.

Notice of Termination (NOT). A formal notice to the EPA or delegated state agency for General Permit site terminating coverage under the permit.

Nourishment. The process of replenishing a beach. It may be brought about naturally, by accretion due to the long-shore transport, or artificially, by the deposition of dredged materials.

Offsite Drainage. Flow of water that originates outside the property.

Onsite Drainage. Flow of water that originates inside the property.

Open Channel. Any conveyance in which water flows with a free surface.

Ordinary High Water Mark. The line on the shore established by the fluctuation of water and physically indicated on the bank (1.5 + years return period)

Outfall. Discharge or point of discharge of a culvert or other closed conduit.

Outwash. Debris transported from a restricted channel to an unrestricted area where it is deposited to form an alluvial or debris cone or fan.

Overflow. Discharge of a stream outside its banks; the parallel channels carrying such discharge.

Overtopping Flood. The flood described by the probability of exceedance and water surface elevation at which flow occurs over a hydraulic structure, highway, watershed divide, or through structure(s) provided for emergency relief.

Peak Flow. Maximum momentary stage or discharge of a stream in flood. Design Discharge.

Pebble. Stone 10 to 75 mm in diameter, including coarse gravel and small cobble.

Perched Water. Ground water located above the level of the water table and separated from it by a zone of impermeable material.

Percolating Waters. Waters which have infiltrated the surface of the land and move slowly downward and outward through devious channels (aquifers) unrelated to stream waters, until they reach an underground lake or regain and spring from the land surface at a lower point.

Perennials. Plant species that persist for multiple seasons.

Permeability. The property of soils which permits the passage of any fluid. Permeability depends on grain size, void ratio, shape and arrangement of pores.

Permeable. Open to the passage of fluids, as for (1) pervious soils and (2) bank-protection structures.

Permanent Erosion Control. The use of BMPs to provide long-term soil stabilization and sediment control with the goals of maintaining slopes and protecting water quality. Permanent BMPs continue to exist beyond the completion of the construction contract.

Permit. An authorization, license, or equivalent control document issued by EPA or an approved state agency to implement the requirements of an environmental regulation.

pH. The pH is universally used to express the intensity of the acid or alkaline condition of a water sample. The pH of natural waters tends to range between 6 and 9, with neutral being 7. Extremes of pH can have deleterious effects on aquatic systems.

Physiographic Region. A geographic area whose pattern of landforms differ significantly from that of adjacent regions.

Phytoremediation. The use of living plants (phyto = plant) to remove pollutants from soil and water by degradation, absorption, or containment. Various species of plants and micro-organisms can be used to metabolize or degrade organic compounds, absorb metal contaminants into the above-ground portion of the plant, and contain or immobilize soil contaminants in the root mass.

Pier. Vertical support of a structure standing in a stream or other body of water. Used in a general sense to include bents and abutments.

Pile. A long, heavy timber or section of concrete or metal that is driven or jetted into the earth or bottom of a water body to serve as a structural support or protection.

Piping. The action of water passing through or under an embankment and carrying some of the finer material with it to the surface at the downstream face.

Plunge. Flow with a strong downward component, as in outfall drops, overbank falls, and surf attack on a beach.

Point of Concentration. That point at which the water flowing from a given drainage area concentrates.

Point Sources. A source of pollutants from a single point of conveyance such as a pipe. For example, the discharge pipe from a sewage treatment plant or factory is a point source.

Poised Stream. A term used by river engineers applying to a stream that over a period of time is neither degrading or aggrading its channel, and is nearly in equilibrium as to sediment transport and supply.

Positive Projecting Conduit. A structure installed in shallow trench with the top of the conduit projecting above the top of the trench and then covered with embankment. See Negative Projecting Conduit.

Potamology. The hydrology of streams.

Practicable. Capable of being done within reasonable natural, social, and economic constraints.

Precipitation. Discharge of atmospheric moisture as rain, snow or hail, measured in depth of fall or in terms of intensity of fall in unit time.

Prescriptive Rights. The operation of the law whereby rights may be established by long exercise of their corresponding powers or extinguished by prolonged failure to exercise such powers.

Preserve. To avoid modification to the• functions of the natural floodplain environment or to maintain it, as closely as practicable, in its natural state.

Probability. The chance of occurrence or recurrence of a specified event within a unit of time, commonly expressed in 3 ways. Thus a 10-year flood has a chance of 0.1 per year and is also called a 10%-chance flood.

Probability of Exceedance. The statistical probability, expressed as a percentage, of a hydrologic event occurring or being exceeded in any given year. The probability (p) of a storm or flood is the reciprocal of the average recurrence interval (N).

Probable Maximum Flood. The flood discharge that may be expected from the most severe combination of critical meteorological and hydrological conditions that are reasonably possible in the region.

Pumping Plant. A complete pumping installation including a storage box, pump or pumps, standby pumps, connecting pipes, electrical equipment, pumphouse and outlet chamber.

Rack. An open upright structure, such as a debris rack.

RainfalL Point Precipitation: That which registers at a single gauge. Area Precipitation: Adjusted point rainfall for area size.

Rainwash. The creep of soil lubricated by rain.

Range. Difference between extremes, as for stream or tide stage.

Rapidly Varied Flow. In this type of flow, changes in depth and velocity take place over short distances, acceleration forces dominate, and energy loss due to friction is minor.

Rapids. Swift turbulent flow in a rough steep reach.

Ravine. A valley larger than a gulch, smaller than a canyon, and less bold in relief than a gulch or arroyo.

Reach. The length of a channel uniform with respect to discharge, depth, area, and slope. More generally, any length of a river or drainage course.

Recession. Retreat of shore or bank by progressive erosion.

Reef. Generally, any solid projection from the bed of a stream or other body of water.

Regime. The system or order characteristic of a stream; its behavior with respect to velocity and volume, form of and changes in channel, capacity to transport sediment, amount of material supplied for transportation, etc.

Regimen. The characteristic behavior of a stream during ordinary cycles of flow.

Regulatory Floodway. The open floodplain area that is reserved in by Federal, State, or local requirements, i.e., unconfined or unobstructed either horizontally or vertically, to provide for the discharge of the base flood so that the cumulative increase in water surface elevation is no more than a designated amount (not to exceed 0.3048 m as established by the Federal Emergency Management Agency (FEMA) for administering the National Flood Insurance Program (NEIIP)).

Regulatory Framework. A particular set of laws, rules, procedures, and agencies designed to govern a particular type of activity or solve a particular program.

Reliction. Pertaining to being left behind. For example: that area of land is left behind by reliction when the water surface of a lake is lowered.

Repose. The stable slope of a bank or embankment, expressed as an angle or the ratio of horizontal to vertical projection.

Restore. To reestablish a setting or environment in which the functions of the natural and beneficial floodplain values adversely impacted by a development can continue to operate.

Restriction. Artificial or natural control against widening of a channel, with or without construction.

Retard. Bank-protection structure designed to check the riparian velocity and induce silting or accretion.

Retarding Basin. Either a natural or man made basin with the specific function of delaying the flow of water from one point to another. This tends to increase the time that it takes all the water falling on the extremities of the drainage basin to reach a common point, resulting in a reduced peak flow at that point.

Retention. The holding of runoff in a basin without release except by means of evaporation, infiltration, or emergency bypass.

Retention Storage. Water that accumulates and ponds in natural or excavated depressions in the soil surface with no possibility for escape as runoff. (See Detention Storage)

Retrogression. Reversal of stream grading; i.e., aggradation after degradation, or vice versa.

Re-vegetation. Planting of indigenous plants to replace natural vegetation that is damaged or removed as a result of construction projects or permit requirements.

Revetment. Bank protection to prevent erosion.

Rill Erosion. The formation of numerous, closely spaced streamlets due to uneven detachment of surface soils by runoff on slopes.

Riparian. Pertaining to the banks of a stream.

Ripple. (1) The light fretting or ruffling of a water caused by a breeze. (2) Undulating ridges and furrows, or crests and troughs formed by action of the flow.

Riprap. A layer, facing, or protective mound of broken concrete, sacked concrete, rock, rubble, or stones randomly placed to prevent erosion, scour, or sloughing of a structure or embankment; also, the stone used for this purpose.

Riser. In mountainous terrain where much debris is encountered, the entrance to a culvert sometimes becomes easily clogged. Therefore, a corrugated metal pipe or a structure made of timber or concrete with small perforations, called a riser, is installed vertically to permit entry of

water and prohibit the entry of mud and debris. The riser may be increased in height as the need occurs.

Risk. The consequences associated with the probability of flooding attributable to an encroachment. It includes the potential for property loss and hazard to life during the service life of the structure or project.

Risk Analysis. An economic comparison of design alternatives using expected total costs (construction costs plus risk costs) to determine the alternative with the least expected cost to the public.

River. A large stream, usually active when any streams are flowing in the region.

Rock. (1) Cobble, boulder or quarry stone as a construction material. (2) Hard natural mineral, in formation as in piles of talus.

Rounded Inlet. The edges of a culvert entrance that are rounded for smooth transition, which reduces turbulence and increases capacity.

RSP Fabric. (See Filter Fabric).

Rubble. Rough, irregular fragments of rock or concrete.

Runoff. (1) The surface waters that exceed the soil's infiltration rate and depression storage. (2) The portion of precipitation that appears as flow in streams. Drainage or flood discharge which leaves an area as surface flow or a pipeline flow, having reached a channel or pipeline by either surface or subsurface routes.

Run-up. The rush of water up a beach or structure, associated with the breaking of a wave. The amount of run-up is measured according to the vertical height above still water level that the rush of water reaches.

Sag Culvert (or Sag Pipe). A pipeline with a dip in its grade line crossing over a depression or under a highway, railroad, canal, etc. The term inverted siphon is common but inappropriate as no siphonic action is involved. The term "sag pipe" is suggested as a substitute.

Sampling and Analysis Plan. A document that describes how the samples will be collected and under what conditions, where and when the samples will be collected, what the sample will be tested for, what test methods and detection limits will be used, and what methods/procedures will be maintained to insure the integrity of the sample during collection, storage, shipping and testing (i.e., quality assurance/quality control protocols).

Sand. Granular soil coarser than silt and finer than gravel, ranging in diameter from 0.05 to 5 mm.

Scour. The result of erosive action of running water, primarily in streams, excavating and carrying away material from the bed and banks. Wearing away by abrasive action.

Scour, General. The removal of material from the bed and banks across all or most of the width of a channel, as a result of a flow contraction which causes increased velocities and bed shear stress.

Scour, Local Removal of material from the channel bed or banks which is restricted to a minor part of the width of a channel. This scour occurs around piers and embankments and is caused by the actions of vortex systems induced by the obstruction to the flow.

Scour, Natural. Removal of material from the channel bed or banks which occurs in streams with the migration of bed forms, shifting of the thalweg and at bends and natural contractions.

Sea. Ocean or other body of water larger than a lake; state of agitation of any large body of water.

Seawall. A structure separating land and water areas, primarily designed to prevent erosion and other damage due to wave action. (See bulkhead).

Sediment. Fragmentary material that originates from weathering of rocks and is transported by, suspended in, or deposited by water.

Sedimentation. Gravitational deposit of transported material in flowing or standing water.

Sediment Delivery Ratio. The ratio of sediment yield to erosion rate, typically calculated on an average annual basis.

Sediment Yield. The amount of eroded sediment that is transported to a point of measurement.

Seepage. Percolation of underground water through the banks and into a stream or other body of water.

Seiche. A standing wave oscillation of an enclosed waterbody that continues, pendulum fashion, after the cessation of the originating force, which may have been either seismic or atmospheric.

Seismic Wave. A gravity wave caused by an earthquake.

Semi-Arid Area. Area receiving between 10 and 20 inches of rainfall per year.

Settleable Solids. The settleable solids (SS) test measures the solid material that can be settled within a water column during a specified time frame. This typically is tested by placing a water sample into an Imhoff settling cone and allowing the solids to settle by gravity. Results are reported either as a volume (mL/L) or a weight (mg/L).

Sheet Erosion. Erosion of thin layers of soil by sheets of flowing water.

Sheet Flow. Any flow spread out and not confined; i.e., flow across a flat open field.

Sheet Pile. A pile with a generally slender, flat cross-section that is driven into ground or bottom of a water body and meshed or interlocked with like members to form a wall or bulkhead.

Shod. A shallow region in flowing or standing water, especially if made shallow by deposition.

Shoaling. Deposition of alluvial material resulting in areas with relatively shallow depth.

Shore. The narrow strip of land in immediate contact with the water, including the zone between high and low water lines. See backshore, foreshore, onshore, offshore, long-shore, and near-shore.

Silt. (1) Water-Borne Sediment. Detritus carried in suspension or deposited by flowing water, ranging in diameter from 0.005 to 0.05 mm. The term is generally confined to fine earth, sand, or mud, but is sometimes both suspended and bedload. (2) Deposits of Water-Borne Material. As in a reservoir, on a delta, or on floodplains.

Sinuosity. The ratio of the length of the river thalweg to the length of the valley proper.

Skew. When a drainage structure is not normal (perpendicular) to the longitudinal axis of the highway, it is said to be on a skew. The skew angle is the smallest angle between the perpendicular and the axis of the structure.

Slide. Gravitational movement of an unstable mass of earth from its natural position.

Slipout. Gravitational movement of an unstable mass of earth from its constructed position. Applied to embankments and other man-made earthworks.

Slope. (1) Gradient of a stream. (2) Inclination of the face of an embankment, expressed as the ratio of horizontal to vertical projection; or (3) The face of an inclined embankment or cut slope. In hydraulics it is expressed as percent or in decimal form.

Slough. (1) Pronounced SLU. A side or overflow channel in which water is continually present. It is stagnant or slack; also a waterway in a tidal marsh. (2) Pronounced SLUFF. Slide or slipout of a thin mantle of earth, especially in a series of small movements.

Slugflow. Flow in culvert or drainage structure that alternates between full and partly full. Pulsating flow -- mixed water and air.

Soffit. The bottom of the top -- (1) With reference to a bridge, the low point on the underside of the suspended portion of the structure. (2) In a culvert, the uppermost point on the inside of the structure.

Soil Amendment. Soil amendments and mulches are any material that is added to the soil to change its chemical properties, engineering properties, or erosion resistance that could become mobilized by storm water and would be not visible in the runoff. Soil amendments include lime, cementitious binders, chlorides, emulsions, polymers, soil stabilizers, and tackifiers applied as a stand-alone treatment (i.e., without mulch). Plant fibers (such as straw or hay), wood and recycled paper fibers (such as mulches and matrices), bark or wood chips, green waste or composted organic materials, and biodegradable or synthetic blanket fibers would be also be included as soil amendments.

Source Control BMP. An effort to prevent or limit the exposure of significant materials to storm water at the source.

Specific Energy. The energy contained in a stream of water, expressed in terms of head, referred to the bed of a stream. It is equal to the mean depth of water plus the velocity head of the mean velocity.

Spur Dike. A structure or embankment projecting a short distance into a stream from the bank and at an angle to deflect flowing water away from critical areas.

Stage. The elevation of a water surface above its minimum; also above or below an established “low water” plane; hence above or below any datum of reference; gage height.

Standing Wave. (1) The motion of swiftly flowing stream water, that resembles a wave, but is formed by decelerating or diverging flow that does not quite produce a hydraulic jump. (2) A term which when used to describe the upper flow regime in alluvial channels, means a vertical oscillation of the water surface between fixed nodes without appreciable progression in either an upstream or downstream direction. To maintain the fixed position, the wave must have a celerity (velocity) equal to the approach velocity in the channel, but in the opposite direction.

Steady Flow. A flow in which the flow rate or quantity of fluid passing a given point per unit of time remains constant.

Stone. Rock or rock-like material; a particle of such material, in any size from pebble to the largest quarried blocks.

Storage. Detention, or retention of water for future flow, naturally in channel and marginal soils or artificially in reservoirs.

Storage Basin. Space for detention or retention of water for future flow, naturally in channel and marginal soils, or artificially in reservoirs.

Storm. A disturbance of the ordinary, average conditions of the atmosphere which, unless specifically qualified, may include any or all meteorological disturbances, such as wind, rain, snow, hail, or thunder.

Storm Drain. That portion of a drainage system expressly for collecting and conveying former surface water in an enclosed conduit. Often referred to as a "storm sewer," storm drains include inlet structures, conduit, junctions, manholes, outfalls and other appurtenances.

Storm Water. Storm water runoff, snow melt runoff, and surface runoff and drainage.

Storm Water Management. The recognition of adverse drainage resulting from altered runoff and the solutions resulting from the cooperative efforts of public agencies and the private sector to mitigate, abate, or reverse those adverse results.

Storm Water Pollution Prevention Plan (SWPPP). A plan required by the Permit that includes site map(s), an identification of construction/contractor activities that could cause pollutants in the storm water, and a description of measures or practices to control these pollutants. It must be prepared and approved before construction begins. A SWPPP prepared in accordance with the special provisions and the Handbooks will satisfy Standard Specifications Section 7-1.OIG - Water Pollution, requirement for preparation of a program to control water pollution.

Strand. (1) To lodge on bars, banks, or overflow plain, as for drift. (2) Bar of sediment connecting two regions of higher ground.

Stream. Water flowing in a channel or conduit, ranging in size from small creeks to large rivers.

Stream Power. An expression used in predicting bed forms and hence bed load transport in alluvial channels. It is the product of the mean velocity, the specific weight of the water-sediment mixture, the normal depth of flow and the slope.

Stream Response. Changes in the dynamic equilibrium of a stream by any one, or combination of various causes.

Stream Waters. Former surface waters which have entered and now flow in a well defined natural watercourse, together with other waters reaching the stream by direct precipitation or rising from springs in bed or banks of the watercourse. They continue as stream Waters as long as they flow in the watercourse, including overflow and multiple channels as well as the ordinary or low-water channel.

Strutting. Elongation of the vertical axis of pipe before installing in a trench. After the backfill has been placed around the pipe and compacted, the wires or rods holding the pipe in its distorted shape are removed. Greater side support from the earth is developed when the pipe tends to return to its original shape. Generally used on pipes which, because of size or thinness of the metal, would tend to deform during construction operations. Arches are strutted diagonally per standard or special plan.

Subcritical Flow. In this state, gravity forces are dominant, so that the flow has a low velocity and is often described as tranquil and streaming. Also defined as flow that has a Froude number less than one.

Subdrain. A conduit for collecting and disposing of underground water. It generally consists of a pipe, with perforations in the bottom through which water can enter.

Subsidence. A general lowering of the land surface by consolidation or removal of underlying soil.

Substrate. The layer of earth or rock that lies immediately below the surface soil.

Sump. In drainage, any low area that does not permit the escape of water by gravity flow.

Supercritical Flow. In this state, inertia forces are dominant, so that flow has a high velocity and is usually described as rapid, shooting and torrential. Also defined as flow that has a Froude number greater than one.

Support Base Floodplain Development. To encourage, allow, serve, or otherwise facilitate additional base floodplain development. Direct support results from an encroachment, while indirect support results from an action out of the base floodplain.

Surcharge. A condition where the hydraulic capacity of the storm drain system is temporarily exceeded (e.g., during a storm event), and the amount of water that enters the system exceeds the conveyance capacity.

Surf The breaking of waves and swells on the foreshore and offshore shoals.

Surface Runoff The movement of water on earth's surface, whether flow is over surface of ground or in channels.

Surface Waters. Surface waters are those which have been precipitated on the land from the sky or forced to the surface in springs, and which have then spread over the surface of the ground without being collected into a definite body or channel. They appear as puddles, sheet or overland flow, and rills, and continue to be surface waters until they disappear from the surface by infiltration or evaporation, or until by overland or vagrant flow they reach well-defined watercourses or standing bodies of water like lakes or seas.

Surge. (1) A sudden swelling of discharge in unsteady flow. (2) A large mass of moving water, such as a wave or swell. Also a heavy, violent swelling motion, such as a surge of water through a storm drain during a heavy rain.

Suspended Load. Sediment that is supported by the upward components of turbulent currents in

a stream and that stay in suspension for appreciable amount of time.

Suspended Sediment. Eroded soil particles that are suspended in wind or water.

Suspended Sediment Concentration (SSC). The suspended sediment concentration (SSC) test measures the concentration of suspended solid material in a water sample by measuring the dry weight of all of the solid material from a known volume of a collected water sample. Results are reported in mg/L.

Suspended Solids. Organic or inorganic particles which are suspended in and carried by the water. The term includes sand, mud and clay particles as well as solids in wastewater.

Swale. A shallow, gentle depression in the earth's surface. This tends to collect the waters to some extent and is considered in a sense as a drainage course, although waters in a swale are not considered stream waters.

Swamp. An area of shallow pondage or saturated surface, the water being fresh or acidic and the area usually covered with rank vegetation.

Swell. Waves generated by a distant storm, usually regular and fully harmonic.

Talus. Loose rocks and debris disintegrated from a steep hill or cliff standing at repose along the toe.

Tapered Inlet. A transition to direct the flow of water into a channel or culvert. A smooth transition to increase hydraulic efficiency of an inlet structure.

Temporary Construction Site BMPs. BMPs that are required only to address a short-term water contamination threat, specifically throughout the duration of the construction contract. water contamination threat, specifically soil stabilization and sedimentation. Temporary BMPs are implemented throughout, but not beyond, the duration of the construction contract.

Terrace. Berm or bench-like earth embankment, with a nearly level plain bounded by rising and falling slopes.

Tetrahedron. Bank protection element, basically composed of 6 steel or concrete struts joined like the edges of a triangular pyramid, together with subdividing struts and tie wires or cables.

Tetrapod. Bank protection element, pre-cast of concrete, consisting of 4 legs joined at a central block, each leg making an angle of 109.5 degrees with the other three, like rays from the center of a tetrahedron to the center of each face.

Texture. The arrangement and interconnection of surface and near-surface particles of terrain or channel perimeter.

Thalweg. The line following the lowest part of a valley, whether under water or not. Usually the line following the deepest part of the bed or channel of a river.

Thread. The central element of a current, continuous along a stream.

Tide. The periodic rising and falling of the ocean and connecting bodies of water that results from gravitational attraction of the moon and sun acting on the rotating earth.

Time of Concentration. The time required for storm runoff to flow from the most remote point, in flow time, of a drainage area to the point under consideration. It is usually associated with the design storm.

Topography. The physical features of a surface area including relative elevations and the position of natural and man-made features.

Topping. The top layer on horizontal revetments or rock structures; also capping or cap stones.

Total Maximum Daily Load (TMDL). A process established by the Clean Water Act to guide the application of state water quality standards to individual water bodies and watersheds by defining the amount of a particular pollutant that a water body can absorb on a daily basis without violating applicable water quality standards. Once this load is determined, the regulatory agency allocates a portion to each source of that pollutant within a particular watershed.

Total Suspended Solids (TSS). Suspended solids in a water sample include inorganic substances, such as soil particles and organic substances, such as algae, aquatic plant/animal waste, particles related to industrial/sewage waste, etc. The total suspended solids test (TSS) test measures the concentration of suspended solids in water by measuring the dry weight of a solid material contained in a known volume of a sub-sample of a collected water sample. Results are reported in mg/L.

Training. Control of direction of currents.

Transition. A relatively short reach or conduit leading from one waterway section to another of different width, shape, or slope.

Transport. To carry solid material in a stream in solution, suspension, saltation, or entrainment.

Trash Rack. A grid or screen across a stream designed to catch floating debris.

Tributary. A river or stream which flows into a larger river or stream.

Trough. Space between wave crests and the water surface below it.

Trunk (or Trunk Line). In a drainage system, the main conduit for. transporting the storm waters. This main line is generally quite deep in the ground so that laterals coming from fairly long distances can drain by gravity into the trunk line.

Tsunami. A gravity wave caused by an underwater seismic disturbance (such as sudden faulting, landsliding or volcanic activity).

Turbidity. Cloudiness of water quantified by the degree to which light traveling through a water column is scattered by the suspended organic and inorganic particles it contains. Scattering of light, increases with a greater suspended load. Turbidity is commonly measured in Nephelometric Turbidity Units (NTU).

Turbulence. The state of flow wherein the water is agitated by cross-currents and eddies, as opposed to a condition of flow that is quiet and laminar.

Turbulent Flow. That type of flow in which any particle may move in any direction with respect to any other particle, and in which the head loss is approximately proportional to the square of the velocity.

Undercut. Erosion of the low part of a steep bank so as to compromise stability of the upper part.

Underfiow. The downstream flow of water through the permeable deposits that underlie a stream. (1) Movement of water through a pervious subsurface stratum, the flow of percolating water; or water under ice, or under a structure. (2) The rate of flow or discharge of subsurface water.

Undertow. Current outward from a wave-swept shore carrying solid particles swept or scoured from the beach or foreshore.

Unsteady Flow. A flow in which the velocity changes with respect to space and time.

Updrift. The direction opposite that of the predominant movement of littoral materials.

Uplift. Upward hydrostatic pressure on the base of an impervious structure.

Urban Runoff. A substance, such as rain, that runs off of surfaces in a watershed in excess of the amount absorbed by the surfaces (usually the ground). Urban runoff can contain sediments and contaminants (non-point source pollution) that can add to water quality degradation in the watershed. Increases in impervious surface usually result in increased urban runoff.

Velocity Head. A term used in hydraulics to represent the kinetic energy of flowing water. This "head" is represented by a column of standing water equivalent in potential energy to the kinetic energy of the moving water, calculated as (V^2 /2g), where the "V" represents the velocity in meters per second and "g" represents the potential acceleration due to gravity, in meters per second per second.

Vernal Pools. Vernal pools are seasonally flooded landscape depressions that support distinctive (and many times rare) plant and animal species adapted to periodic or continuous inundation during the wet season, and the absence of either ponded water or wet soil during the dry season.

Wash. Flood plain or active channel of an ephemeral stream, usually in recent alluvium.

Water Pollution Control The use of practices and measures to prevent the discharge of contaminants to downstream water bodies from construction activities. Various temporary and permanent BMPs for soil stabilization, sediment control, tracking control, wind erosion, non-storm water control, waste management and materials pollution control are included in water pollution control.

Water Pollution Control Program (WPCP) A program that must be prepared and implemented by the construction contractor under Standard Specifications Section 7-1.O1G - Water Pollution.

Water Table. The surface of the groundwater below which the void spaces are completely saturated.

Watercourse. A definite channel with bed and banks within which water flows, either continuously or in season. A watercourse is continuous in the direction of flow and may extend laterally beyond the definite banks to include overflow channels contiguous to the ordinary channel. The term does not include artificial channels such as canals and drains, except natural channels trained or restrained by the works of man. Neither does it include depressions or swales through which surface or errant waters pass.

Waters of the United States. (a) All waters, which are currently used, were used in the past, or may be susceptible to use in interstate or foreign commerce, including all waters which are subject to the ebb and flow of the tide; (b) All interstate waters, including interstate wetlands; (c) All other waters such as intrastate lakes, rivers, streams (including intermittent streams), mudflats, sandflats, wetlands, sloughs, prairie potholes, wet meadows, playa lakes, or natural ponds, the use, degradation, or destruction of which would affect or could affect interstate or foreign commerce including any such waters: (1) which are or could be used by interstate or foreign travelers for recreational or other purposes; (2) from which fish or shellfish are or could be taken and sold in interstate or foreign commerce; or (3) which are used or could be used for industrial purposes by industries in interstate commerce; (d) All impoundments of waters identified in paragraphs (a) through (d) of this definition; (f) The territorial sea; and (g) Wetlands adjacent to waters (other than waters that are themselves wetlands) identified in paragraphs (a) through (f) of this definition. Waste treatment systems, including treatment ponds or lagoons designed to meet the requirements of CWA (other than cooling ponds as defined in 40 CFR

423.11(m) which also meet the criteria of this definition) are not waters of the United States. This exclusion applies only to manmade bodies of water which neither were originally created in waters of the United States (such as disposal area in wetlands) nor resulted from the impoundment of waters of the United States.

Watershed. The area that contributes surface water runoff into a tributary system or water course.

Waterway. (1) That portion of a watercourse that is actually occupied by water. (2) A navigable inland body of water.

Wave. (1) An oscillatory movement of water on or near the surface of standing water in which a succession of crests and troughs advance while particles of water follow cyclic paths without advancing. (2) Motion of water in a flowing stream so as to develop the surficial appearance of a wave.

Wave Height. The vertical distance between a wave crest and the preceding trough.

Wave Length. The horizontal distance between similar points on two successive waves (for example, crest to crest or trough to trough), measured in the direction of wave travel.

Wave Period. The time in which a wave crest travels a distance equal to one wave length. Can be measured as the time for two successive wave crests to pass a fixed point.

Weep hole. A hole in a wall, invert, apron, lining, or other solid structure to relieve the pressure of groundwater.

Weir. A low overflow dam or sill for measuring, diverting, or checking flow.

Well.~ (1) An artificial excavation for withdrawal of water from underground storage. (2) The upward component of velocity in a stream.

Wetland. Those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas.

Windbreak. (1) A barrier fence or line of trees to break or deflect the velocity of wind. (2) Any device designed to block wind flow and intended for protection against any ill effects of wind, particularly wind erosion.

Windwave. A wave generated and propelled by wind blowing along the water surface.

Young. Immature, said of a stream on a steep gradient actively scouring its bed toward a more stable grade.

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